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THE CONSTRUCTION OF THE GARDEN CITY PROJECT FOR THE UNITED STATES RECLAMATION SERVICE

BY

GEORGE ROBERTSON KEACHIE

A THESIS SUBMITTED FOR THE DEGREE OF

CIVIL ENGINEER

UNIVERSITY OF WISCONSIN

1907

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C O N T E N T S

CHAPTER 1

CONDITIONS in the region about Garden City before the Project was conceived; Conditions at the present time.

GENERAL STATEMENT of the nature of the investigations which determined the building of the Project; Results expected.

CHAPTER 11

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CONDITIONS met with during construction affecting the work. Freight conditions; Inaccessability of supply and repair shops; Weather conditions.

CHAPTER 111

MANAGEMENT of the work of construction; Office force; Forms used in cost keeping; method of cost keeping and exceptions noted thereto.

CAMP MANAGEMENT. Location of Camps; Location of Store Houses and Work Shops.

CHAPTER 1V

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SOUTH CONDUIT EMBANKMENT:

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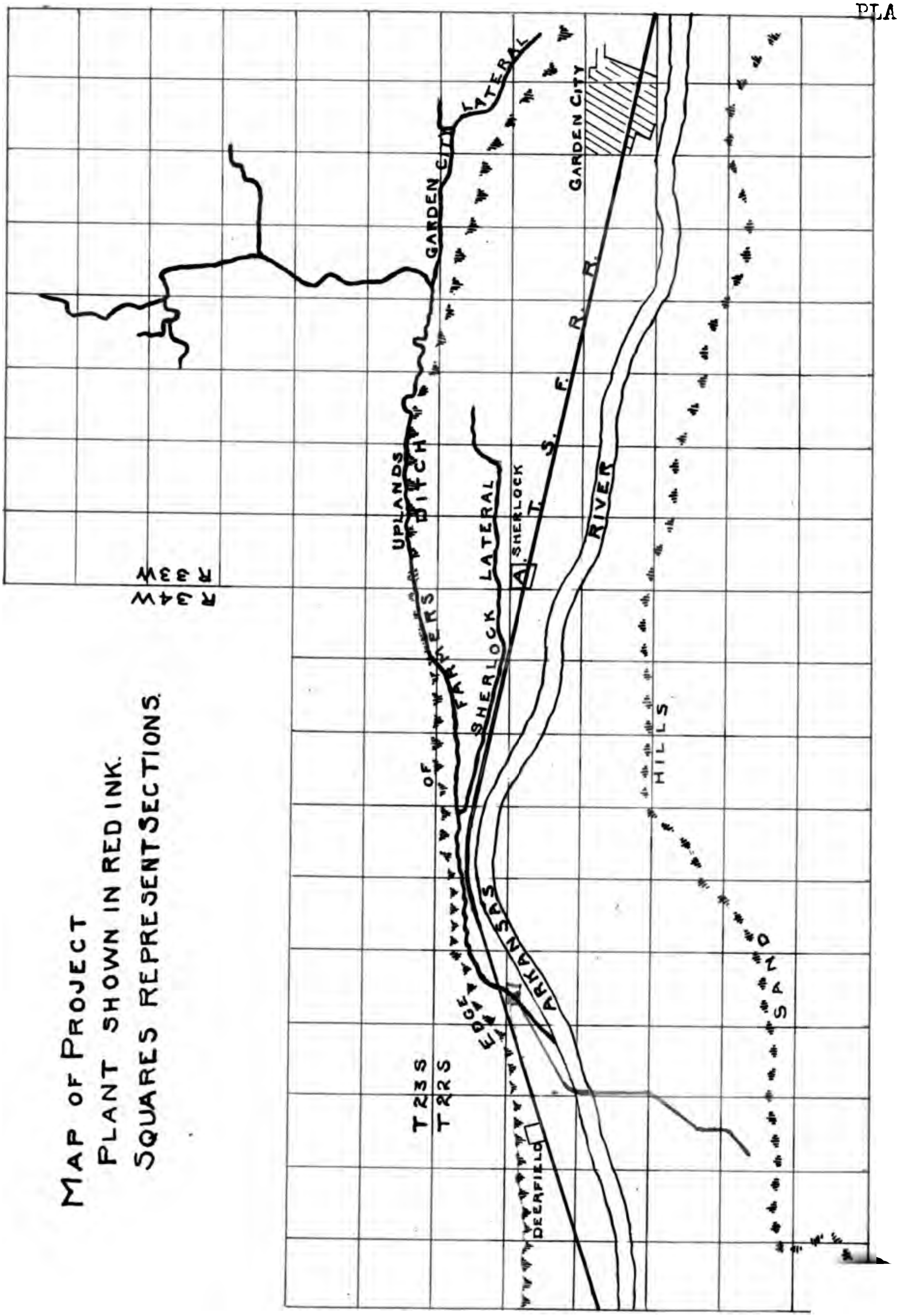


MAP OF PROJECT
PLANT SHOWN IN RED INK.
SQUARES REPRESENT SECTIONS.

(1)

THE GARDEN CITY PROJECT

The Reclamation Project known as the Garden City Project is so called for the reason that the land to be supplied with water for irrigation purposes lies adjacent to Garden City, Kansas, and for the further reason that this town is the only place of any size near the location of the Project proper. The plant supplying the water is located at Deerfield, fourteen miles west of Garden City, on the line of The Atchison, Topeka & Santa Fe Railroad. (Plate 1)

Garden City is well within that portion of the west, where a rainfall sufficient for raising crops, cannot be depended upon. Twenty years ago this country was even more settled than it was up to a few years ago. Successive seasons of drought following the first years of prosperity, depreciated the value of the land, and many settlers moved away. Then ditches were dug, by which to take water from the Arkansas River. But the river supply is not to be depended upon, either. At the time the water from the river is needed, the river supply comes mainly from melting snows in the Colorado mountains, and a mild season in Colorado or an early thaw, might either result in little water coming down or in early freshets coming when the fields were not prepared to receive the water. Moreover

there are numerous large ditches drawing water from the river, further up stream, and there are several large reservoirs in which the river water is impounded. Thus the river supply is not to be fully relied upon though some water may always be counted upon.

There is a source of water supply in the Arkansas Valley which is being put to more use every successive season. The underground water stands on the average at about six feet below the surface of the ground in the valley. This supply is fed mainly by the rainfall which falls on the sand hills to the south of the river, and it is in movement in the general direction of the river at about eight feet per day. It is from this underground flow that the Garden City Project is to derive its water, the plant being designed to pump up this water when the rainfall has not been sufficient, and when the river will not fill the ditch into which the plant is to deliver the water pumped.

The ground itself is very good. Most excellent crops of alfalfa, wheat, cane and kaffir corn may be grown. But by far the most paying thing to raise is the sugar beet. The ground is very level in this region, and it has a slope which permits of easy irrigation. Moreover, sugar beets, to be raised to great advantage, should be grown in a country which is irrigated and which has periods when no rain falls. This region, if water can be depended on for irrigation, will greatly increase in value and will be ideal for the raising of sugar beets.

Last Fall a sugar beet factory was completed at Garden City, which is this year to be enlarged by the installation of more machinery in the present building so that its daily capacity will be twelve hundred tons of beets. The company building the factory has acquired an enormous acreage, some thirty thousand acres, together with the control of three ditches, two being on the north side of the Arkansas River and one on the south side. The company's land is scattered for twenty miles or more up the Arkansas Valley and is all located so as to be "under ditches". These ditches take water from the Arkansas River at a point about thirty miles above Garden City.

Realizing that the river is not to be depended upon it was necessary for the beet company either to store up the water of the freshets or the winter water, or else to pump up the water from the underground flow. A natural depression was discovered about three miles north west of Deerfield and near two of the company's ditches. This depression has been converted by the construction of an earthen dam into an immense reservoir, which is expected to impound water capable of irrigating fifty thousand acres. This reservoir will supply the two ditches on the north side of the river. For the ditch on the south side it is proposed to install a series of plants to pump up the underground flow. Thus, with the Garden City Project supplying the fourth ditch, considerable of the ground can be watered, crops will be assured, and the land will

greatly increase in value.

Before the Project was begun we find a country capable of development, but lacking water. We now find the two methods of supplying water about to be put into operation; a reservoir as against a large plant for pumping up the underflow. The land is being put under ditches and there is in operation on the spot a factory to use the most profitable crop which may be grown in the region, namely, the sugar beet.

The investigation carried on by the Reclamation Service consisted mainly of the necessary test wells to determine the amount of ground water that might be recovered, and also to fix the best location for the wells. The location of the wells fixed the location of the Project, the proper location of the power house and the location of the old irrigating ditch, known as the Farmers' Ditch, which is. to receive the water pumped being considered when the most advantageous location for the wells was decided upon. Further, a form of strainer was selected after considerable experimental testing, which would give the greatest amount of water, the size of the well and the material penetrated being considered.

As a result of the investigations, it was decided to install twenty three sets of wells, with a pump for each set, thirteen well stations being on the south side and ten on the north side of the Arkansas River. Each set of

wells consists of nine shallow wells from forty to sixty feet deep, and one deep well to rock, except that at the initial station there is to be one large well consisting of a concrete cylinder twelve feet in diameter inside and about forty feet deep, the sides being perforated with numerous conical holes to admit the water. The well stations are spaced at intervals of one thousand feet and three well stations will empty directly into the Farmers' Ditch. The other well stations will discharge into a concrete conduit approximately twenty thousand feet long. The conduit increases in size from a square box conduit of 2.7 sq. ft. cross section, to a trapazoidal conduit 4.8 ft. wide at the bottom and of 22.9 sq. ft. cross section. The water is carried from the south to the north side of the river, by means of a wooden stave pipe buried underneath the river bottom. The conduit discharges into the Farmers' Ditch which carries the water for some fourteen miles where it is distributed over the uplands north of Garden City.

Prior to the beginning of the Project, an Association of Farmers controlling the Farmers' Ditch formed the Water Users' Association, and made contracts with the United States for the necessary water to irrigate 8,600 acres at a fixed rate and for a certain length of time. At the end of the period the accumulated charges for water will re-imburse the Government for the cost of the Project, whereupon the plant will become the property of the Water Users' Association.

The wells are expected to supply 150 second feet, and

to maintain this supply for 150 days if necessary. It is expected that the plant will be capable of supplying enough water to irrigate twice the amount contracted for, or in all some 17,000 acres.

CONDITIONS MET WITH
DURING CONSTRUCTION OF PROJECT

Bids were invited on this work to be opened July 6th, Sufficient time for the making of an intelligent bid had not been given; consequently no acceptable bid was received, and it was ordered that bids be asked for again on September 28th, 1906. Again no satisfactory bids were received. Thereupon it was ordered that the work be done by "Force Account".

There are several reasons in the writer's opinion, why no bids were received, and why no great attention even was paid to the work by contractors. The chief reason is that this job was just a little too large for a small contractor, and it was too small for a large contractor; therefore, neither kind would touch the work under contract. Again, the Specification contains many conditions to fulfill which would be practically impossible if they were to be rigidly adhered to. As an instance, the specification concerning the steel read as follows; "A variation in cross section of more than 2.5% from that specified will be considered sufficient cause for rejection". The material men flatly refused to quote under this specification. The Specification contained several such points which will be brought up as each is reached, and it will be shown that in doing its own work,

the Government did not handicap itself as it would most certainly have handicapped a contractor had he been compelled to follow the conditions of his contract.

In making himself acquainted with the work when expecting to bid on it, the writer became acquainted with the Engineers in charge of the Project, and he was eventually contracted for to superintend the construction of the Project (except the sinking of the wells which was let by contract) and to furnish his outfit, foreman, and a number of his own workmen.

The conditions found in this locality affected the work in no small measure. There is but one railroad, the A. T. & S. F., which seemed incapable of handling its business. Cars containing live stock were over four days in coming from Kansas City, a distance of about 500 miles, and regular freight would be weeks on the road. The construction of the power house was delayed for several months until enough brick had arrived with which to make a start. For several months there was no Agent at Deerfield, and whenever a car was put on the siding the writer used to break the seal to see if it contained anything for the Project. It was found that the only dependable way to get an order was to have the goods expressed. This proved costly, when such articles as an orange-peel bucket and other heavy pieces of machinery had to be shipped in in this way.

For repairs or supplies, there was no near depot. At Garden City there was no iron for blacksmith repairs to be

had, even from junk dealers. We used to visit the scrap heaps at the railroad section houses for several stations above and below Deerfield. The nearest machine shop is 150 miles away, except that, at the beet factory the company maintains a first class little repair shop for its own use. If it had not been for the kindness of the officials of this company our work would certainlyhave had to stop many times. For instance, the pistons of the pumps used in jetting broke frequently; we always succeeded in turning others out at the factory within twelve hours. We used nearly 2,000 lbs. of iron from a pile of odds and ends at the factory, and to cap the climax, they dismounted a molasses pump which they loaned us to couple on to the jetting line so as to provide more water for driving the piles. The presence of this beet factory certainly saved the Government hundreds of dollars.

The weather was remarkable. Not twenty days were lost through the whole winter. Usually two days at a time would be the length of a bad spell. We had no rain of consequence until May. For some ten days in January the ground froze too hard for the plows to break and wheel scraper work had to be suspended,but the ditch work was continued. In March, on the 19th, it was as hot as 92 degrees. We were bothered most by terrific hot winds which carried sand and made it very unpleasant to work. But on the whole the winter was exceedingly favorable and I am told was very exceptional for this country.

If it had been easier to get shipments of material and tools, and if there had been supply houses within reasonable reach, the work would have been completed in at least six weeks' less time, and at a great saving of money and effort.

(111)

MANAGEMENT

OF THE WORK OF CONSTRUCTION

The chief authority on the work was vested in the Project Engineer, who had to assist him an Engineering Aid of three years' service and one just appointed to the Service; the writer who was in immediate charge of the construction; a time keeper; a store house keeper; a bookeeper and a stenographer. The financial matters were in charge of a Special Disbursing Officer.

In cost keeping the basis was the daily time sheet, a form proposed by the writer. The foreman stated the name of the workman, the hours worked, and made a distribution of the workman's time down to a half hour showing whatever various sections of the work the man was engaged on. Every man not on the office force appeared on the daily time report. It was the bookeeper's work to figure up the cost of the various time items according to a schedule of divisions required by the Washington office.

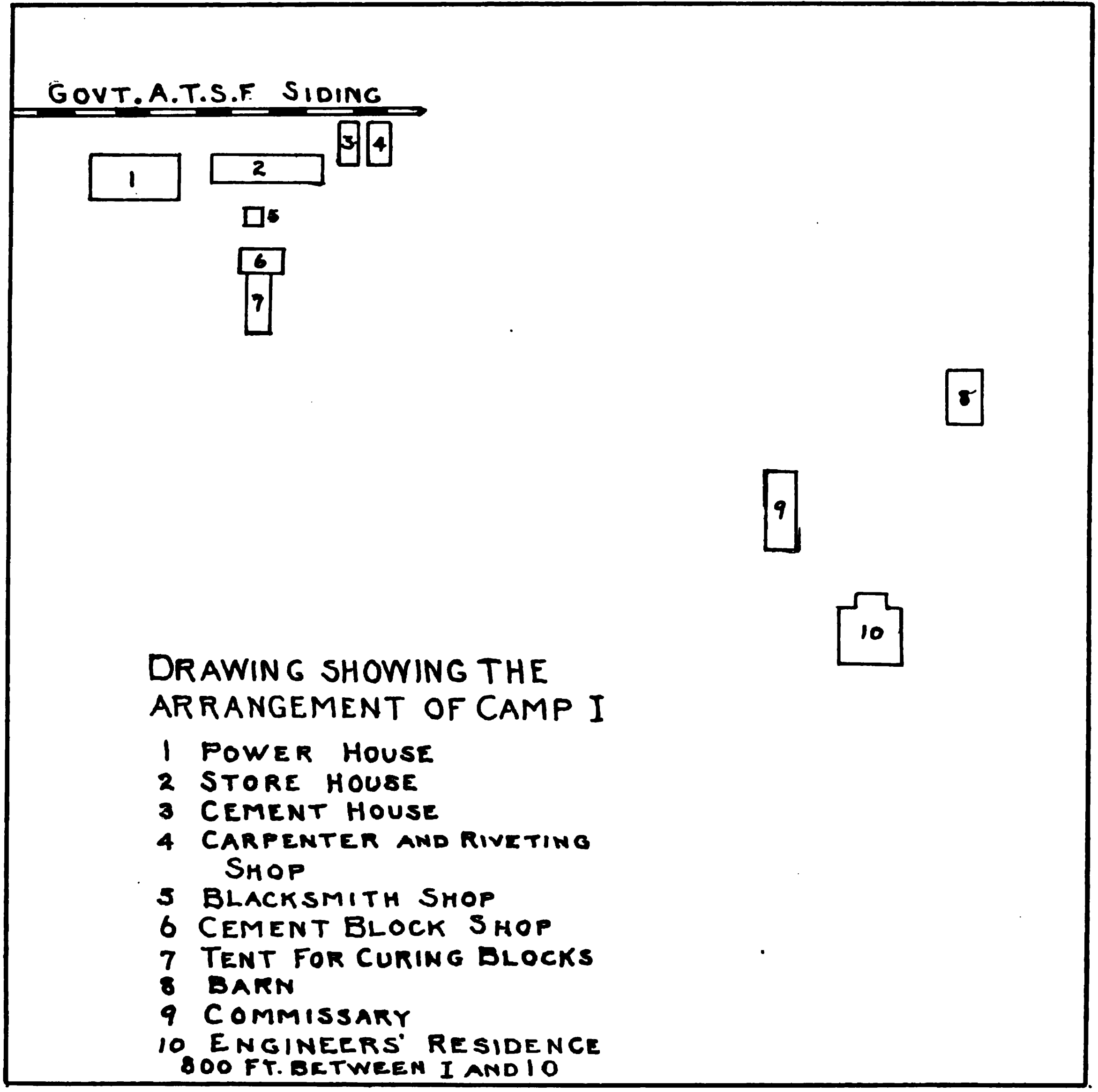
Material and equipment were drawn from the store house on triplicate requisitions upon a form sent out from the Washington Office. Each requisition stated the feature of the Project for which the material or equipment was desired.

A piece of equipment was put into stock and was charged to a feature by the first requisition taking it out of stock; and on its return to the storehouse the feature was credited

by the amount previously debited. Obviously such a procedure would not give a correct charge, if a fine degree of cost keeping were expected. Take an example I have in mind, A pair of pipe tongs purchased for permanent equipment, to be used on the plant after construction was completed, was charged on a feature for its full value the first time it was taken out of the storehouse. If the tool was lost the charge would have stood. When the tool was returned, the charge was canceled and charged again when next taken out. Some charge ought to have been made against each feature the tool was used on. In the writer's opinion, the proper thing to do in such a case would be to add up the total cost of equipment used in this way and to apportion this cost among the features the tools were used on in the ratio of the valuation of the sum of the cost of the labor and material of the various features. Of course equipment purchased and used for a special feature should be charged to that feature, as for example the pumps and boiler used at the river crossing . The fact remains in the writer's opinion, that the present Government method of keeping cost is not as correct as it should be for the expense incurred.

In my presentation of the cost I have not followed the divisions as called for by the Departmental Schedule, but have tried to arrive very closely at what each separate step of a feature cost. In the Government's division, earthwork per yard is arrived at by dividing the total number of yards into the total cost, although part of the earthwork was put up by

Plate II



DRAWING SHOWING THE ARRANGEMENT OF CAMP I

1 POWER HOUSE
2 STORE HOUSE
3 CEMENT HOUSE
4 CARPENTER AND RIVETING SHOP
5 BLACKSMITH SHOP
6 CEMENT BLOCK SHOP
7 TENT FOR CURING BLOCKS
8 BARN
9 COMMISSARY
10 ENGINEERS' RESIDENCE
800 FT. BETWEEN I AND 10

Plate III

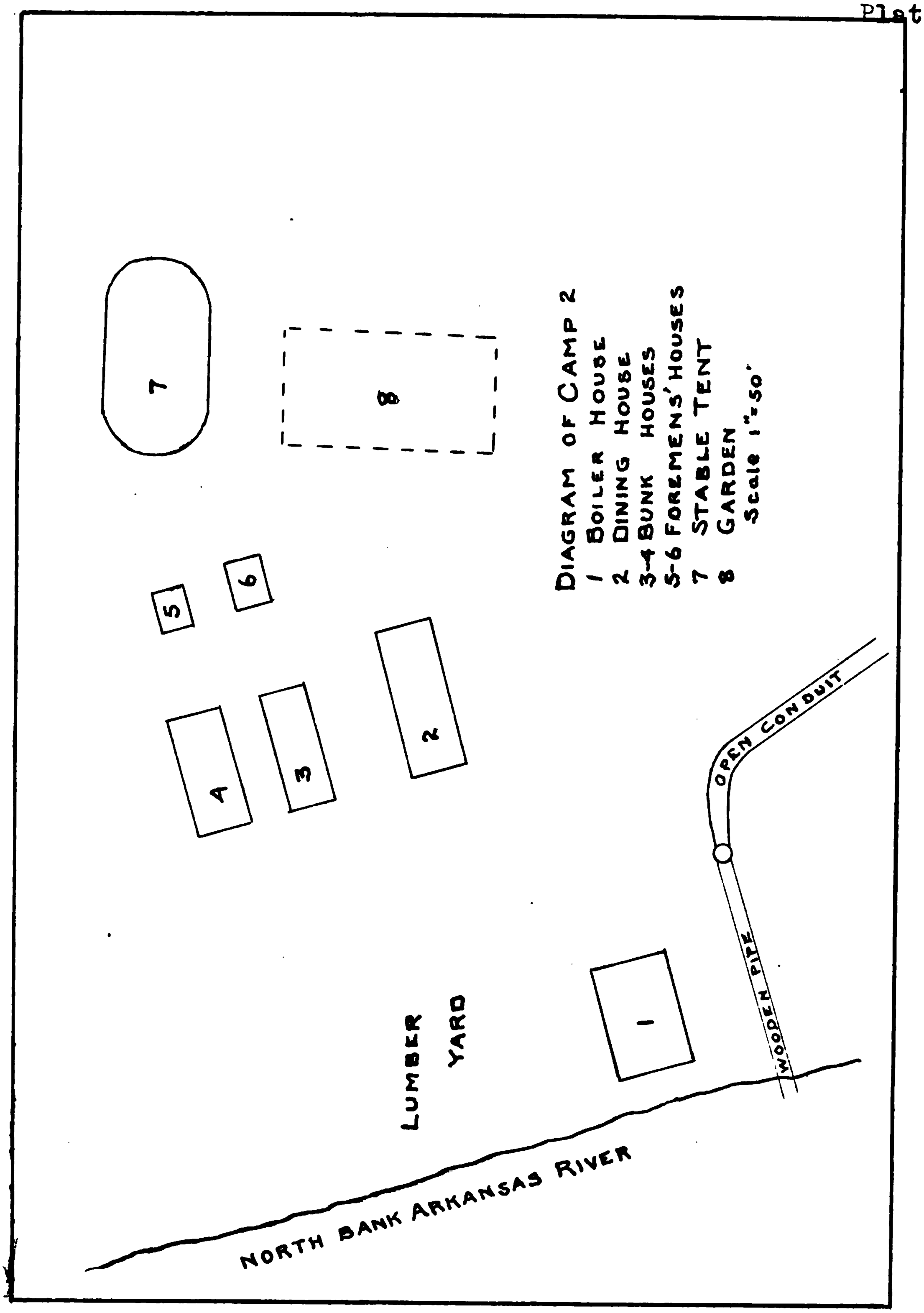


DIAGRAM OF CAMP 2
1 BOILER HOUSE
2 DINING HOUSE
3-4 BUNK HOUSES
5-6 FOREMENS' HOUSES
7 STABLE TENT
8 GARDEN
Scale 1"=50'
1
2
3
4
5
6
7
8
LUMBER YARD
NORTH BANK ARKANSAS RIVER
OPEN CONDUIT
WOODEN PIPE

slips in a fill three feet high and part by wheelers in a fill eight feet high. Again, in figuring the cost of concrete, no division was made between hand mixing and machine mixing, nor was any division made because of the shape in which the concrete was formed. The Government will know what the average cost of concrete was per yard but the result will be of no use in estimating what concrete would cost per yard of a certain shape similar to a certain portion of the concrete on this work.

The extended nature of the work made it necessary to have several camps, the locations of which are shown on the accompanying drawings, (Plates 2, 3) The majority of the men were housed at Camp 2, where there were two bunk houses and a dining house. The houses were made of 12" boards, dressed on one side, the sides and roofs being tar-papered and battened. In building the houses care was taken to choose dimensions which would keep the lumber in sizes suitable for salvage. The rise in the prices of lumber made it possible to recover nearly all the original cost of the material.

The fixed price for board on all Government work (25¢ per meal) made it possible to furnish excellent board at a sufficient saving to pay for the original cost of the camp houses.

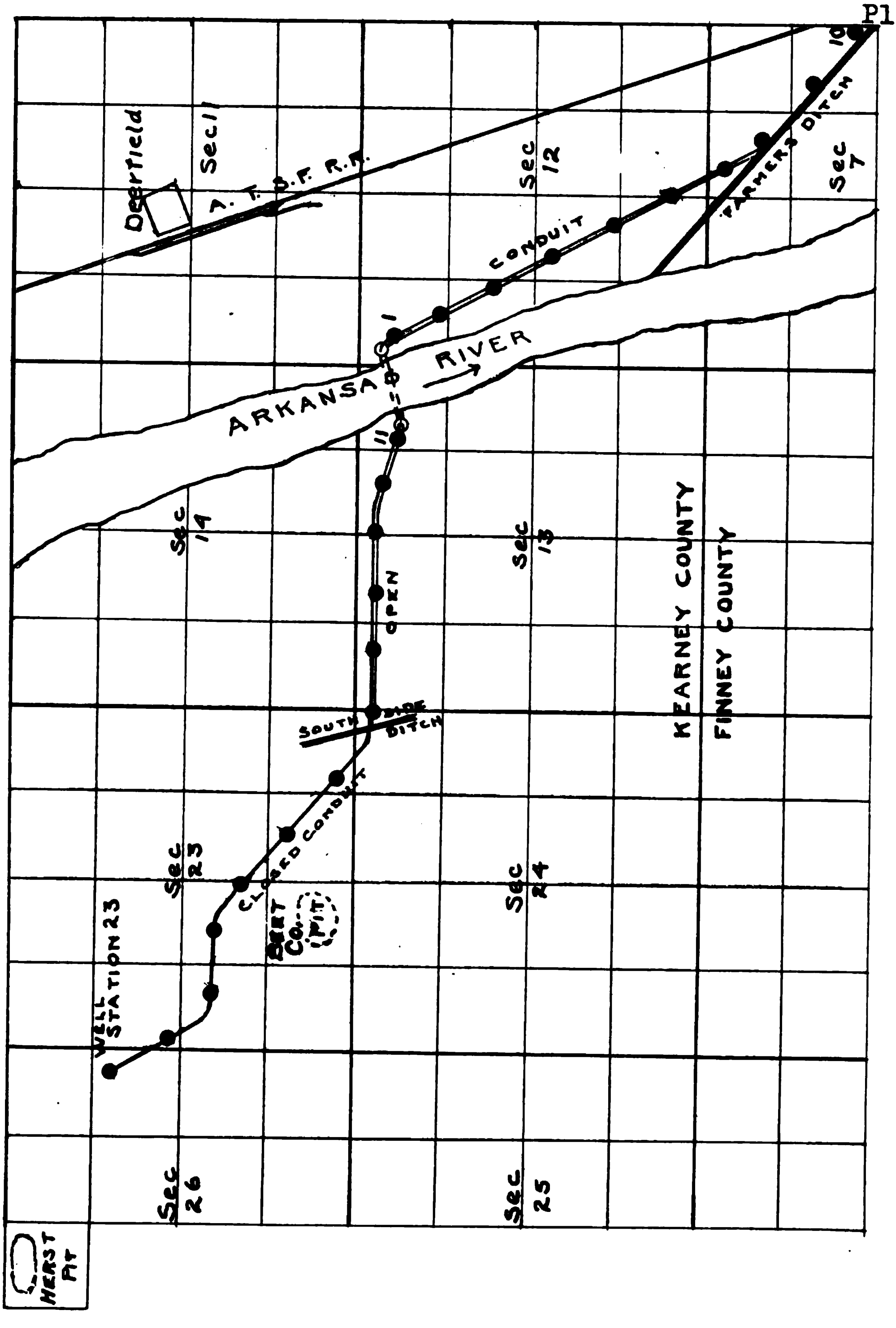
The men who did the earthwork on the north side, the river crossing, and the work at the power house, lived at Camp 2. The men who put in the embankment on the south side, the south side conduit and the north side conduit, lived at

Camp 3. When the north side conduit was built we could not abandon Camp 3, because we had to have it later on; so we had the teamster who hauled cement take the men over and back morning and night, and also take them to dinner, at practically no additional expense for the work.

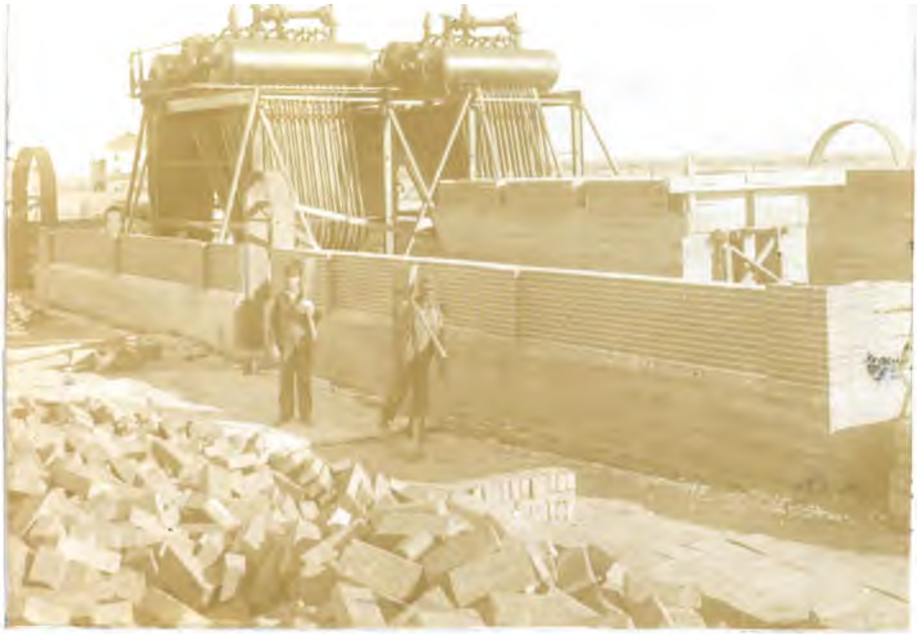
Each camp was in charge of a Foreman who saw to keeping the premises cleaned up; saw to it that the bunk houses were cleaned periodically; adjusted disputes with the cooks; and kept watch against gambling and the bringing in of liquor. We did not have a single fight, and discharged only one man for using liquor.

As shown on the drawing for Camp 1, a side track was built to the location of the power house by the Government. A long store house, 100 ft. x 20 ft. housed most of the material. Two smaller buildings were used, one in which to store cement and the other to rivet well casing in and as a carpenter shop. These two buildings were located so that the cars could be directly unloaded into them. The blacksmith shop was located for a time in the workhouse, and later moved into a separate building as shown. The siding and arrangement of the storehouses made the receiving of the material comparatively easy and economical.

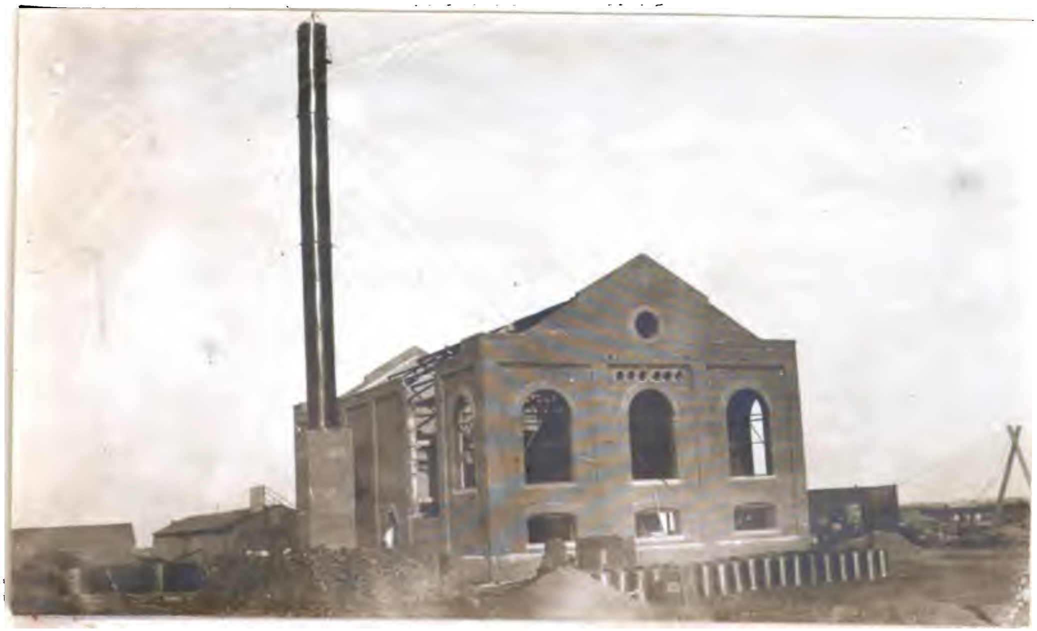
Plate IV



MAP OF PLANT

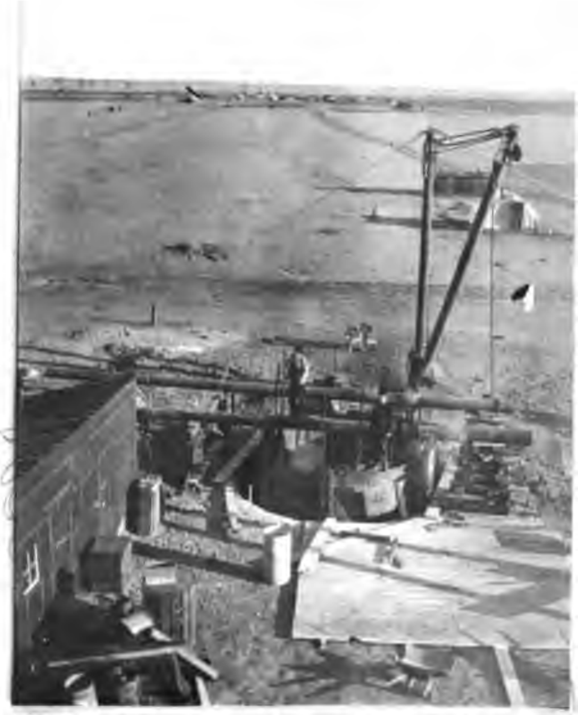


POWER HOUSE
SHOWING WALL FOUNDATIONS
TURBINE FOUNDATIONS
MOUNTED BOILERS



POWER HOUSE, NEARING COMPLETION

PLATE V



BIG WELL
IN COURSE OF CONSTRUCTION
SHOWING STEEL FORM -- AND
DERRICK FOR OPERATING THE
ORANGE PEEL BUCKET, CAMP
NO. 2, ---- IN BACKGROUND

(IV)

THE WORK OF CONSTRUCTION

Following is a list of the various features of the Project the construction of which will be described.

EARTH WORK:

North Conduit Embankment

South Conduit Embankment

Excavation for Closed Conduit.

CONCRETE WORK:

Farmers' Ditch Lining

Open Conduit -- Lining of Concrete
in North and South Embankments

Closed Conduit

WOODEN STAVE PIPE:

Piling

Excavation

Concrete Penstock

Wooden Stave Pipe

Besides the above described work the writer had charge of the construction of the concrete foundations and machine and boiler settings for the power house, photographs of which are shown; also of the foundations, walls, and roofs of the pump houses; also of the so-called Big Well intended to supply the condenser water for the turbines installed in the power house. In the aggregate this amounted to considerable work, but considered separately, the writer does not consider any special skill or thought was required in their construction and for this reason their description is not

included.

EARTH WORK

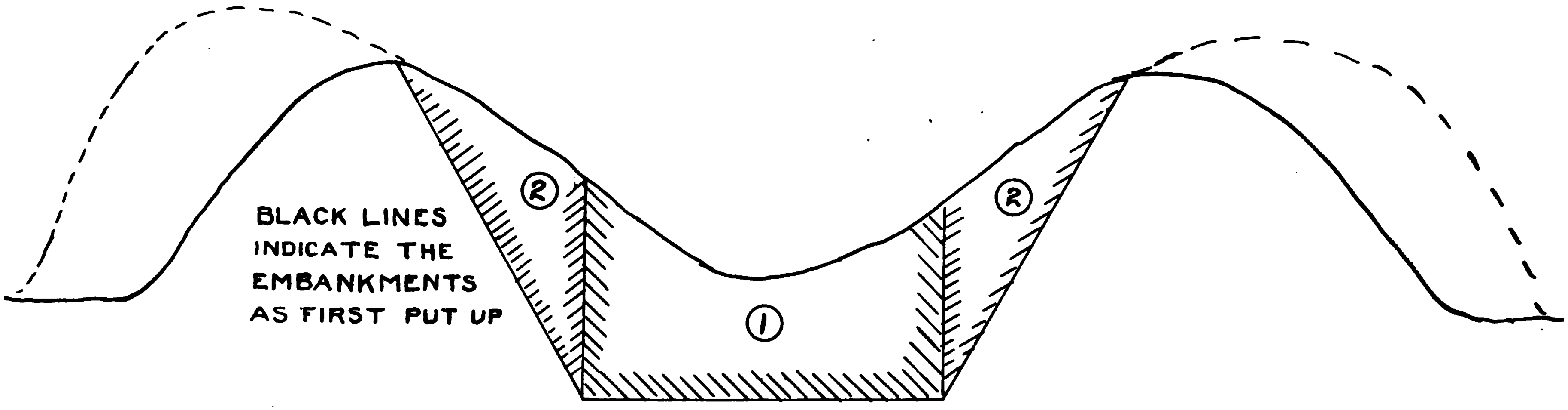
North Conduit Embankment

The North Conduit Embankment runs over the river bottom from the North Penstock to the Farmers' Ditch, a distance of 7,000 ft. The ground was covered by very tough sod of buffalo grass, below which was about two feet of soil and then sand. Water stood at about three feet below the surface, which necessitated rather wide borrow pits and was a considerable factor in the yardage cost. The soil was very hard, necessitating four horses to plow with.

The sod from the location of the fill and from the borrow pits was first removed to the sides, no sod being built into the embankments. The borrow pits were built so as to give a five foot berm on the south side of the fill, while on the north side a space of twenty feet was left on which to pile the aggregate and use the mixer in putting in the concrete lining.

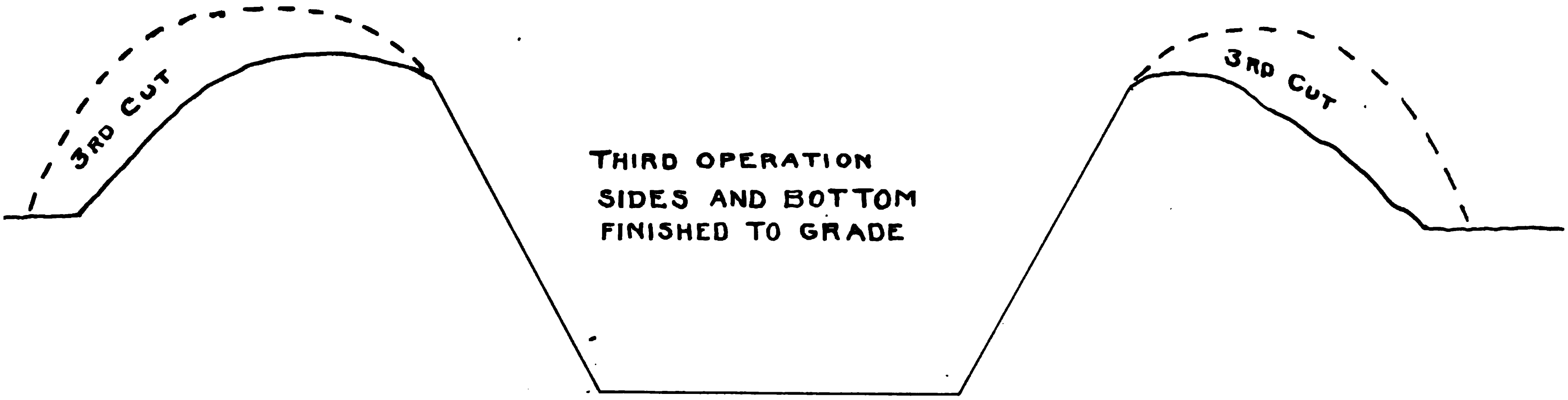
As indicated by the accompanying drawing (Plate VII) the earth was put up in two ridges which were built sufficiently large so that after settlement when the excavation was made to the size of the conduit, the digging would be entirely in settled dirt. The walls of the conduit are on a $\frac{1}{2}$ to 1 slope. Dirt cannot be put up by slips on such a steep slope, consequently more dirt was actually put up than the cross section required, for the reason above stated. The North Conduit Embankment was put up entirely by slip scrapers.

Plate VII



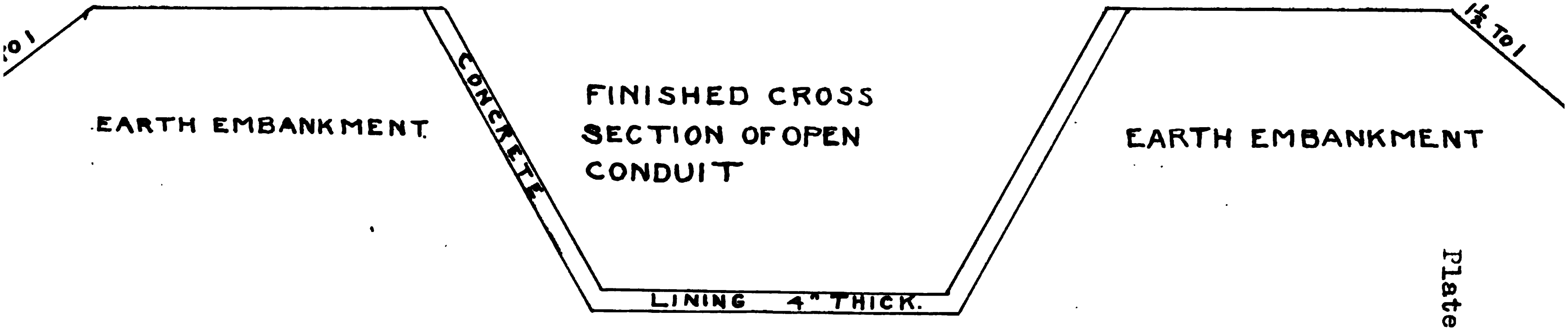
ILLUSTRATING METHOD OF
OPEN CONDUIT EXCAVATION
①-SLOT CUT IN BOTTOM TO
GRADE
②-SIDE CUTS 1' WIDE, 10' APART

Plate VIII



THIRD OPERATION
SIDES AND BOTTOM
FINISHED TO GRADE

ILLUSTRATING METHOD
OF BUILDING OPEN CONDUIT.

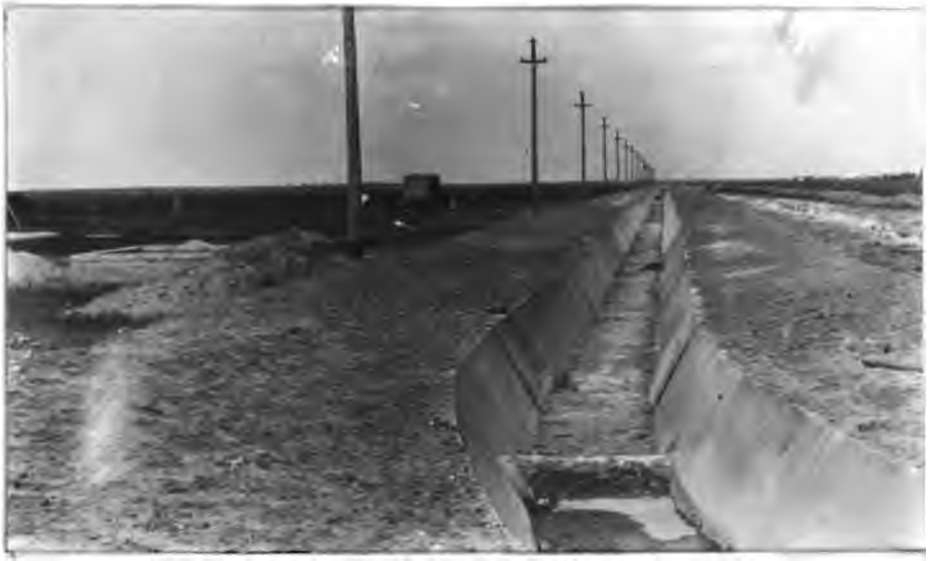


FINISHED CROSS
SECTION OF OPEN
CONDUIT

To settle the fill we mounted a six inch centrifugal pump on the bank of the river near the Penstock and discharged into the upper end of the notch between the embankments. As the water filled up at the lower end, we built dams across the ditch and by backing the water up raised it until the ditch was full. The pump was run day and night and was continued in operation until seepage showed along the sides of the fill.

The accompanying diagrams (Plates VII & VIII) show the variou steps in the process of shaping the embankments to receive the concrete lining. We had grade stakes fifty feet apart, and fifteen feet off center. Center stakes were set in with a hand level one foot above grade; from these side stakes were set, from which lines were stretched so that a slot might be dug the "out-to-out" width of the concrete bottom. The bottom being roughed between the fifty foot stakes, a line was stretched taut from stake to stake and intermediate grade stakes were set ten feet apart which had on them a vertical line showing the center line of the conduit. This operation of laying out the work required only two laborors whose intelligence had to be relied upon, namely the two who set the stakes. The next operation was the digging out of the side walls opposite the stakes set ten feet apart. To get the cross section accurately, the two men who blocked these cuts out each had a form made of 2 x 4's with a center line on the bottom cross piece. By bringing this line on the form over the line on the stake, he could get his cross

Plate IX



VIEW DOWN OPEN CONDUIT, SHOWING
SLOPES TO FINISHED EMBANKMENTS
PUMP HOUSE FOUNDATION TO LEFT

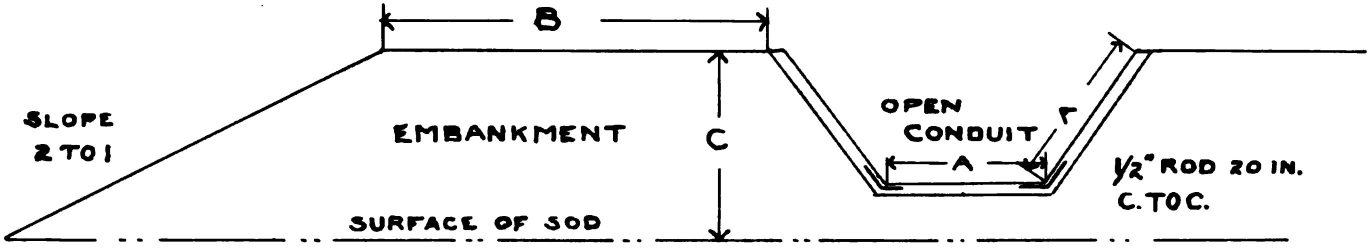
section exactly, and without being able to make an error. From these side slots dug out to section, as guides, it was easy to get a uniform ditch. Two men tamped the side walls and bottom continuously. The cost for this excavation is figured per foot of conduit. This is the proper way, in the writer's opinion, to consider this cost as it is impossible to accurately estimate the yardage removed from a ditch of this kind, except at a very considerable cost. Moreover, a careful excavation as this was should not, in the writer's opinion, be figured by the yard as the Government figures it; it was not even com on shovel work and its cost should not be added into the cost of the slip scraper work to get the cost per yard of embankment. It should rather be figured by the foot of conduit and the price made a portion of the per foot price of the completed conduit.

After the conduit lining was completed, the top of the embankment was leveled off, low spots in the top and sides being filled in by one horse slips since the top width of 4 ft. was too narrow for a team. The outside edge was struck to a line, the men simply sliding the dirt off with square shovels. This finishing went along very rapidly.

South Conduit Embankment

The South Conduit Embankment crosses the river bottoms stretching from the South Penstock to the uplands at the foot of the sand hills, a distance of 4,200 ft. The head necessary to sustain the proper flow of water through the wooden stave pipe which stretches from the south to the north

Plate X



ONE HALF SECTION OF
SOUTH SIDE EMBANKMENT
Scale 1"=4'0"

TABLE OF DIMENSIONS

STATION	A	B	C
70+7 – 80	3.20'	8'	3.3'
80 – 90	3.30'	8'	5.0'
90 – 100	3.40	8'	4.0
100 – 110	3.65	8'	5.3'
110-119+3.4	3.65	8'	5.5

conduit, made it necessary to elevate the south conduit. Moreover, the river bottom on this side has been known to be covered by flood water. Consequently it was decided to build a very substantial bank. As shown by the drawing (Plate X) this embankment has an eight foot top in place of the four foot top used on the north side. The side slopes as shown are on a 2 to 1 slope.

The ground on the south side of the river has less of a dirt covering than that on the north side. We had about three feet of dirt to water. This required borrow pits, 125 ft. wide, the dirt being borrowed from the east side of the embankment only, so that, if the river did overflow its banks there would be no barrow pits on the up-stream side of the embankment to scour out. Most of the south side embankment is coarse sand. The location of the embankment was not stripped of sod, as the bank was so high; the borrow pits were stripped, however.

The bottom two to three feet of the fill were put in with slips. As a rule, we moved the dirt from the thirty foot strip nearest the fill with slips; the balance we put in by wheel scraper. I found it almost impossible to get the men to build their lines straight; so I hit upon the expedient of having a furrow turned on each side to mark the width of the bottom of the fill. This scheme worked very well. The wheeler runs were 400 feet, six wheelers being in one set. We used No. 3 wheelers, two horses to a wheeler, two horses for a"snap"team; two men loading and two men dumping. When

this work was going on in December and January, the frosty nights used to harden the ground, which necessitated four horses on the plow, and by inter fering with the loading of the wheelers, tended to considerably increase the cost. Filling the runways was very expensive. There was hardly enough dirt available down to water so that we had to make long hauls, in places of a thousand feet, to get the dirt necessary to fill the runways.

The best way to settle the fill seemed to be by flooding it. Holes were scooped in the borrow pits to collect water, and a 1½ H. P., Fairbanks-Morse Gas Engine was belted to a 2" Bulldozer Pump, by which 150 ft. sections of the fill were watered. The pumping was kept up day and night until the water stood over the whole top of the section of the fill; little embankments were thrown up along the edge of the top to retain the water.

Before the work could be finished, however, the pump had to be returned. I got a 3" centrifugal pump, belted it to a 4 H. P. Baker Gas Engine and pumped from a 15" well strainer driven ten feet in the borrow pit. An eight inch feeder went about 4 ft. below the bottom of the 15" strainer. This one well was able to support the three inch pump running day and night. From that one set-up we ran the water to the end of the fill, a distance of 3.400 ft., and when the lower end of the fill had been settled, we turned the water into the portion already settled and filled the embankment from end to end. Periodically, we brought the pump back

and watered the fill as the banks worked much better when damp.

The same method of making the excavation for the concrete lining was followed on the south side as on the north side. The sand did not work so well, and as soon as the dirt was thrown out of the ditch it had to be thrown over the bank so that the weight would be taken from the edges of the excavation. The bottom and sides of the excavation were continually tamped, as the digging proceeded, two men being sufficient for this work. The price listed for the excavation in this case carries with it the cost of finishing the grade.

Excavation for Closed Conduit

The Closed Conduit Excavation was done as far as possible with slip scrapers. Two guiding furrows were made and the dirt between scraped out to one side. This method proved to be a very costly one, due principally to the fact that the plowing was so expensive. It took six horses to cut the hard ground met with in this ditch. At the time the work was done we were short of single hands and considered it advantageous to continue with this method even though it was expensive.

In finishing the sides and bottom much the same plan was followed as in the open conduit ditch, except that no form was used for a guide. Grade stakes were set to the invert, a center mark set on them, and the bottom was dug to grade by setting a piece the thickness of the concrete bottom so that the center of the piece met the top and center line of

the stake. The sides were dug out, of course, to clear the ends of the piece, which operation gave the lines for trimming the sides.

CONCRETE WORK

The Cement

The cement used was "Sunflower" Brand, made by The Kansas Portland Cement Company's factories at Iola, Kansas. The cement worked very well. The price at which the cement was supplied was $1.53, F. O. B., factory. A Government Inspector examined each shipment as it was loaded, and made tests on the spot. An average of the many tests made, follows:

SOUNDNESS:

Boiling Test............................O. K.

FINENESS:

Passing #100 Sieve......................93.2%
" #200 " 78.5%

SETTING TIME:

Initial.................................3 hr. 22 min.
Final...................................7 hr. 06 min.

TENSILE STRENGTH (In lbs. per sq. inch)

Neat

1 Day...................................380 lbs.
7 Days..................................989 "
28 Days.................................1043 "

3 Parts Sand to 1 Part Cement;

7 Days..................................298 lbs.
28 Days.................................451 "

The Aggregate

Much difficulty was experienced in finding gravel with sufficient rock content within a reasonable distance of the work. Three locations were found, the location of the two important ones being shown on the drawing (Plate IV).

The gravel from the Beet Company's pit was found in a shallow layer with about a foot of covering. That from Herst's pit was found in a sort of mound or pocket and was of a most excellent grade. One portion of the deposit was exceedingly stony,, which we used to mix with that obtained from the beet pit, and in this way we were able to get a fair grade of aggregate. We also obtained screened gravel from Sherlock, a siding about seven miles east of Deerfield on the A. T. & S. F. Ry. Tests on the material used are as follows:

TESTS ON SCREENED GRAVEL FROM SHERLOCK:

Sample No.	% Mixture Gravel	% Voids In Gravel	% Mixture Sand	% Voids In Sand
1	87½	41½	12½	-------
2	79	33	21	20
3	73	--	27	--
Average	80	37	20	20

Voids in Sand and Gravel Mixed 28%
Mixture has 8% Voids not filled by its Sand content.

TESTS ON SAND AND GRAVEL FROM SUGAR BEET CO'S PIT:

1	29	--	71	29
2	31	--	69	20
3	15	38	85	25
Average	25	38	75	25

TESTS ON GRAVEL FROM HERST'S PIT:

1	37½	--	62½	18
2	37	35	63	23
Average	37	35	63	21

Average Voids of Three Pits;

Gravel................37%
Sand..................22%

PROPORTIONS:

Using Sherlock Gravel nd Sugar Beet Pit Sand;
Basis 27 cu. ft. of gravel;

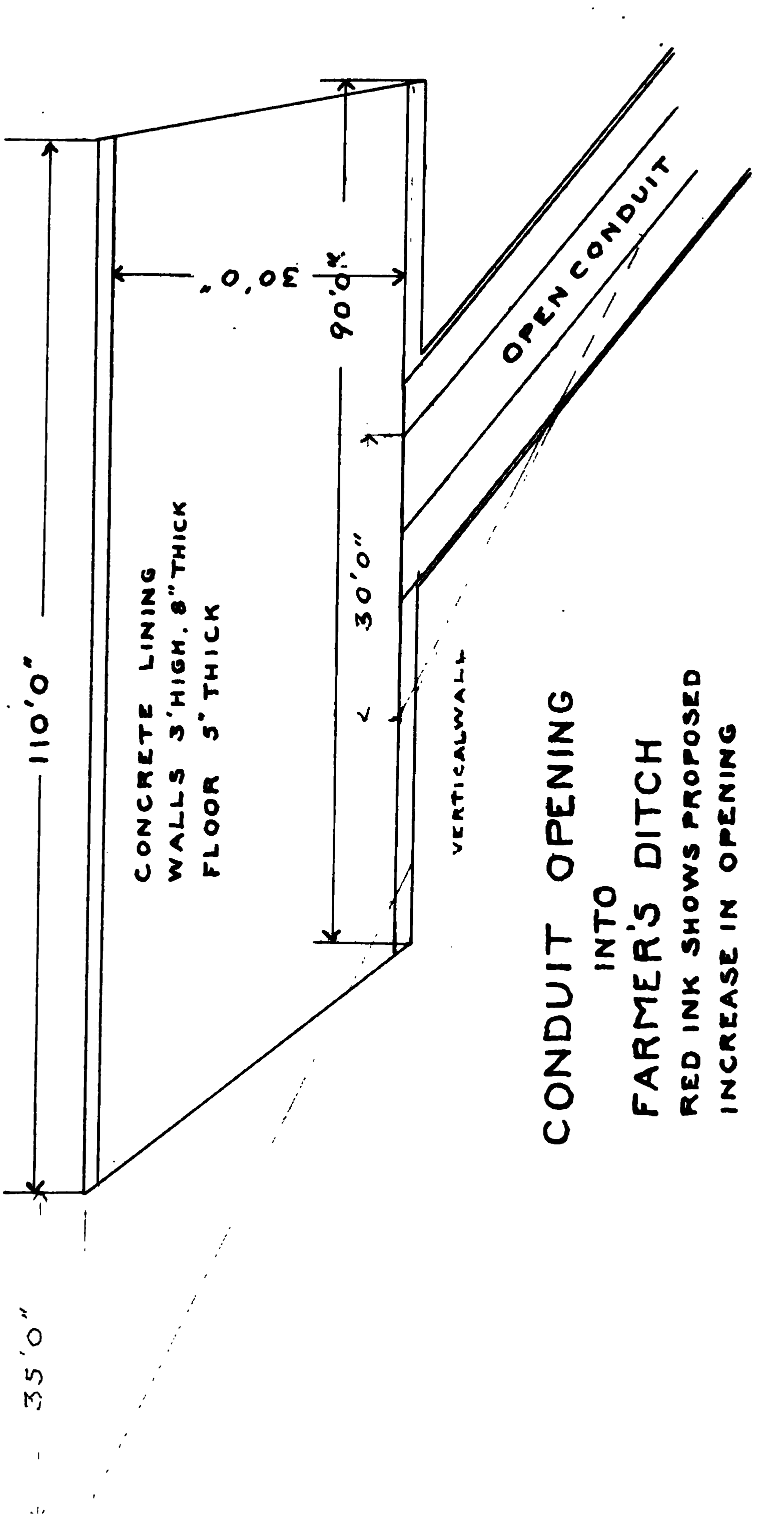
Cubic Ft. Cement	Cubic Ft. Sand	Cubic Ft Gravel
2.83 (22% of 12.9)	10 (37% of 27)	27.0
.28 (10% excess)	2.5(25% of 10)	2.5 Grav. in Sand.
3.11		
	7.5(Sand Bal.)	29.5(Total Grave
	5.4(20% of 27) Sand in Gravel	
	12.9 Total Sand	
3.11 Cu. Ft.	12.9 Cu. Ft.	29.5 Cu. Ft.
Ideal Proportions;		
1 Part	4.2 Parts	9.5 Parts

In practice, we used one barrel of cement to approximately 5.5 Parts of Aggregate, and for every barrel of Cement we got 22.1 ft. of concrete, thus it took 1.20 barrels of cement to 1 cu. yard of concrete.

Farmers' Ditch Lining.

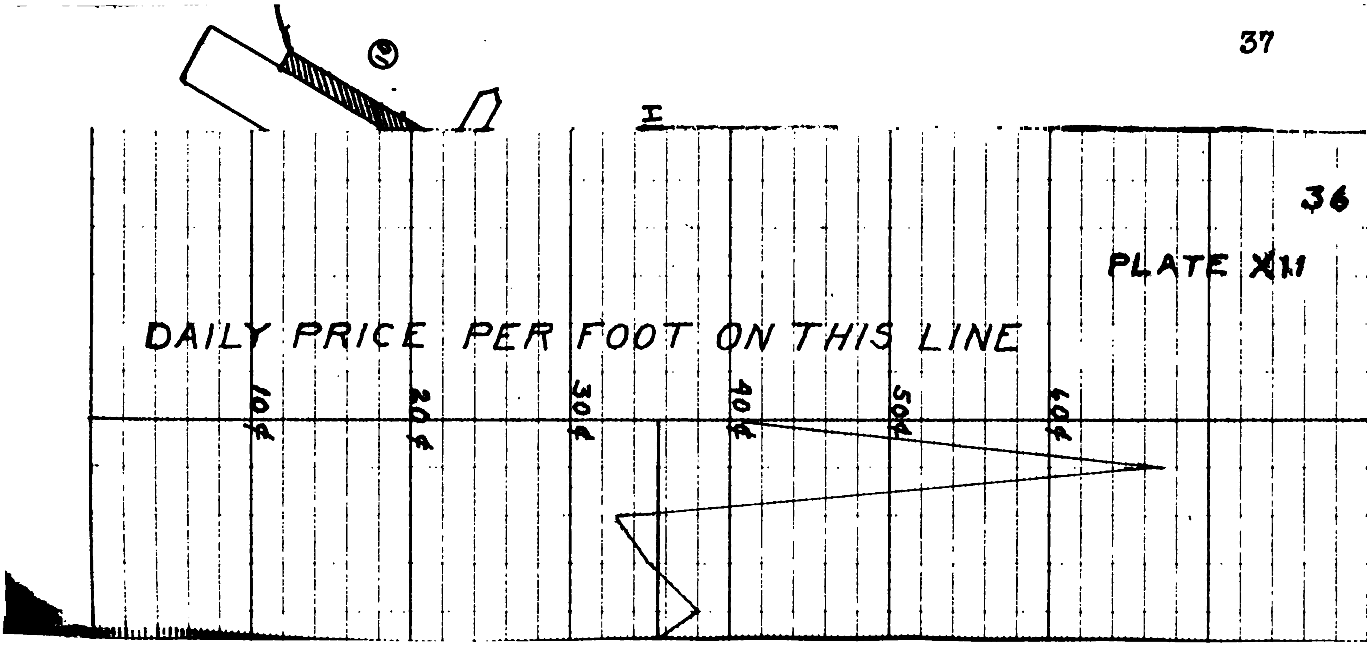
The lining of the Farmers' Ditch at the conduit outlet, required some 70 yards of concrete. The forms for the side walls were first set up and concrete was dumped around the stakes bracing the walls. Then the concrete was turned into the wall forms and by the time a wall was filled, the concrete around the stakes had hardened so as to prevent the bracing for the wall form from moving. This scheme was necessary because the bottom was sand. The wall forms were kept up from the ground the thickness of the floor, so that as the wall was filled, one half of the floor was carried along and smoothed off with the back of the shovel.

Plate XI



CONDUIT OPENING
INTO
FARMER'S DITCH
RED INK SHOWS PROPOSED
INCREASE IN OPENING

PLATE XII


DAILY PRICE PER FOOT ON THIS LINE

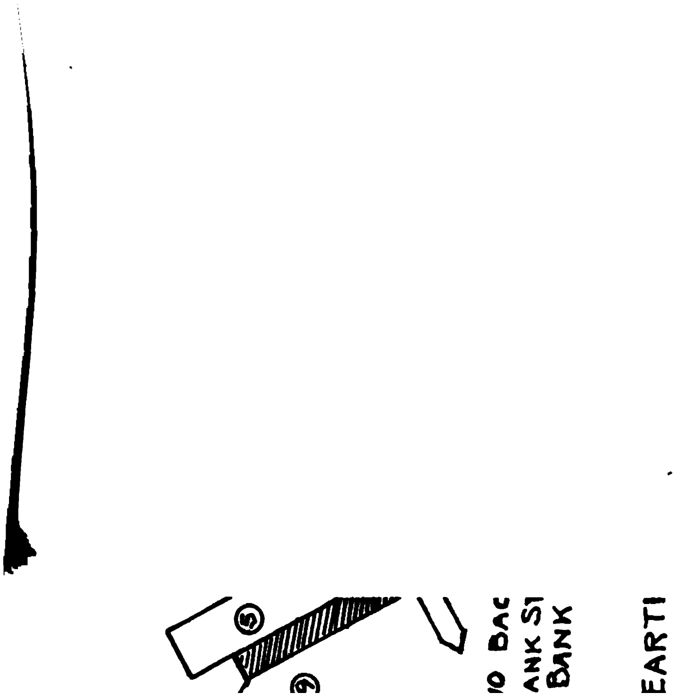
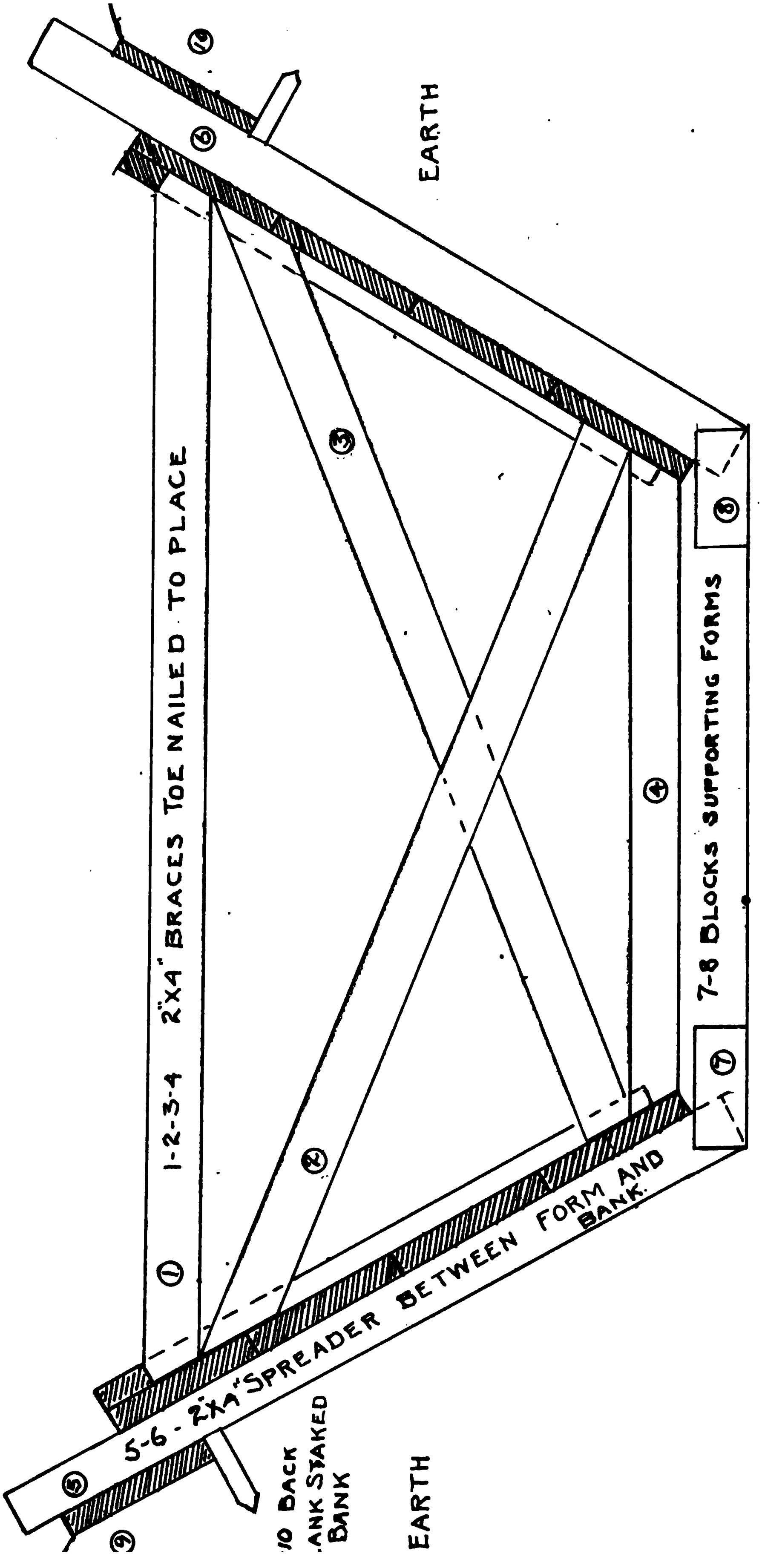


Plate XIII


EARTH
1-2-3-4 2"x4" BRACES TOE NAILED TO PLACE
5-6 - 2"x4" SPREADER BETWEEN FORM AND BANK
7-8 BLOCKS SUPPORTING FORMS
10 BACK
.ANK STAKED
BANK
EARTH
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩

DRAWING SHOWING
OPEN CONDUIT FORMS
Scale 1"=1'

The concrete was put in very wet and required little tamping. The men placing the concrete wore rubber boots and the treading of the concrete tended to settle it amply. In grading the concrete we found the best tool tobe a stiff wire brush of the kind used in street cleaning. No expansion joints were left in either walls or floor. Only one well marked crack has appeared thus far. Drawing, (Plate XI)

OPEN CONDUIT

The open Conduit is some 12,000 ft. long, and this feature offered the best opportunity for developing efficiency in a gang of men. The gang was organized as follows:

One Foreman, ...	$5.00	
One Man fed the Mixer, ...	2.50	
One Man pumped Water, ...	2.50	
One Man dumped the Mixer, ...	2.25	
Three Men wheeled dry stuff, ..	6.75	
One Man helped load dry stuff,	2.25	
Six Men wheeled away concrete,	13.50	
Three men placed the concrete,	7.50	
Four Men set Forms,	11.50	
One Man cleaned out dirt,	2.25	
One Man ran the Engine,	2.50	Total 1 Day. $58.50

The drawing(Plate XI)will indicate the gain in efficiency.

The form setting was laborious work owing to the heavy lifting of the forms in and out of the ditch. On the North Conduit it took six men to lift a form out of the ditch and six to load it on the wagon for movement forward. The drawing (PlateXIIIindicates the method of bracing, which was simple and yet proved to be quite sufficient. The 2 x 4 bracing was used over and over again and one set lasted for nearly 7.000 ft., when the ends were cut down for the next smallest size of conduit, and so used over again.

In setting the forms, a two inch plank, 10 or 12 inches wide was set along the sides, so as to project about four inches above the top line of the conduit. Short stakes were driven into the banks to support these planks, which were used to give a firm backing for the forms, and to give a finished back-edge to the concrete. Then the forms were lifted in and set on short pieces of 2 x 4's, setting edge-wise on the bottom. After the forms were in the ditch, two men handled the rest of the work. One man pried the top of the form over so that a 2 x 4 could be set edge-wise between the form and the banks. Then, by prying up at the bottom or out at the top of the form the cross braces could be inserted and toe-nailed to the forms. When the two forms were thus fastened together, they were brought to line by shifting the bottom with a pry. The pieces under the bottom edges were left in as the walls were filled. When the forms had been taken out they were easily loosened, no stakes or pieces being left in the concrete.

In putting in the concrete the sides were filled first. All the concrete was put in very wet. In putting in the bottom, no attempt was made to rod it off. The bottom line of the wooden form showed well enough in the concrete to act as a guide. The bottom was surfaced with a wire brush and smoothed off with a trowel. The conduit on the north side of the River has no re-inforcement. That on the south side of the River, 4,600 feet long, is re-inforced at the bottom angles with one-half inch rods set 20 inches apart. Drawing(Plate XIII

illustrates the method of form setting used.

The sides of the conduit required a coat of plaster, a 1 to 2 mixture being used. Owing to the hot, dry atmosphere the plaster had to be kept as wet as possible to prevent cracking. The walls were first sprinkled, then the plaster was spread, then smoothed by being brushed with a whitewash brush dipped in water and later sprinkled prior to its setting. About the beginning of May the plaster dried so rapidly that two men were set at work wetting the walls and plaster down with a pump and hose, continually.

Every thirty feet along the open conduit, expansion joints a half inch widebythree inches deep were made by placing a piece of fir siding behind the forms as the walls were built, and in the bottom as it was built. The specification called for the use of steel templates but I found the wooden ones to be better. They were kept wet and were removed while the concrete was still green.

CLOSED CONDUIT:

The form setting for the closed conduit was much easier than that for the open conduit. Here the bottom was put in first, the forms were then set on edge, and spreaders put on top and bottom to keep the sides the proper distance apart, while pieces driven edgewise between the earth and the form, braced the forms together. Most of the closed conduit was put in by hand. A tabulation of the daily progress on this work is not given, because every one thousand feet the size of the conduit changed.

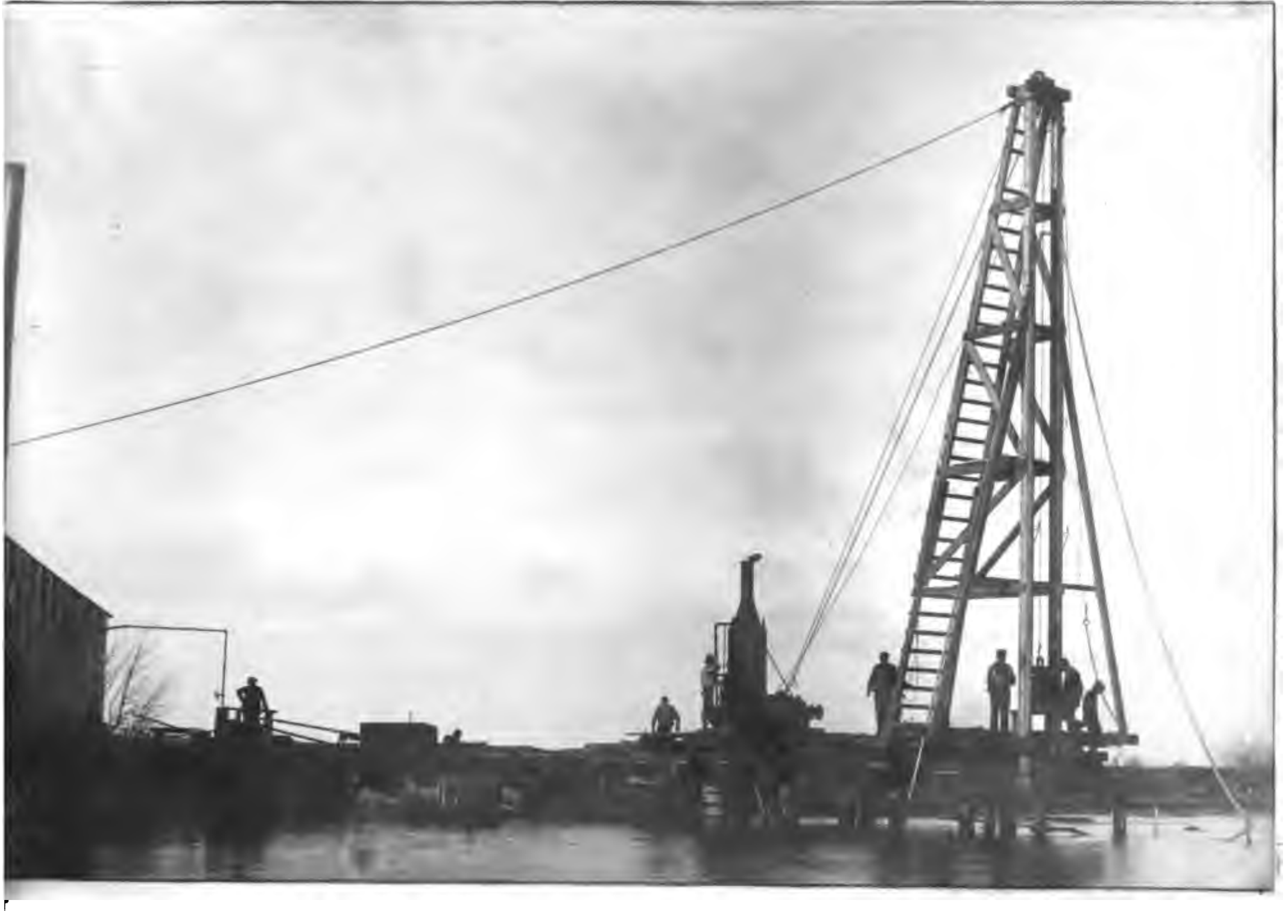
In putting in the top, 2 x 4 posts supported 2 x 4 cross pieces on which were laid planks. No attempt was made to wedge the boards or shim out to prevent cracks. Instead we laid a piece of old tar paper over the space. Nothing was nailed and the forms came out very easily. As a usual thing we left them in only twenty four hours. The top form was laid in stretches of sixty four feet with four foot openings between. To fill these openings, covers of the right length were made on the bank by filling frames made of 2 x 4's. After the forms were removed these covers were set on and the cracks cemented over. The tabulation (Page79) shows the spacing of the ½ inch rod used for re-inforcing. In the last section where the specification called for no rods the first piece put in showed signs of cracking. Examination showed that the boards in the form had bowed up as much as one quarter of an inch. We closed all the openings underneath the form, poured cement water into the cracks which had opened up,

threw water on the top, and then covered it with a layer of sand. We were able in this way to save all the roof. Thereafter, we put a half inch rod about every four feet and had no further trouble.

WOODEN STAVE PIPE

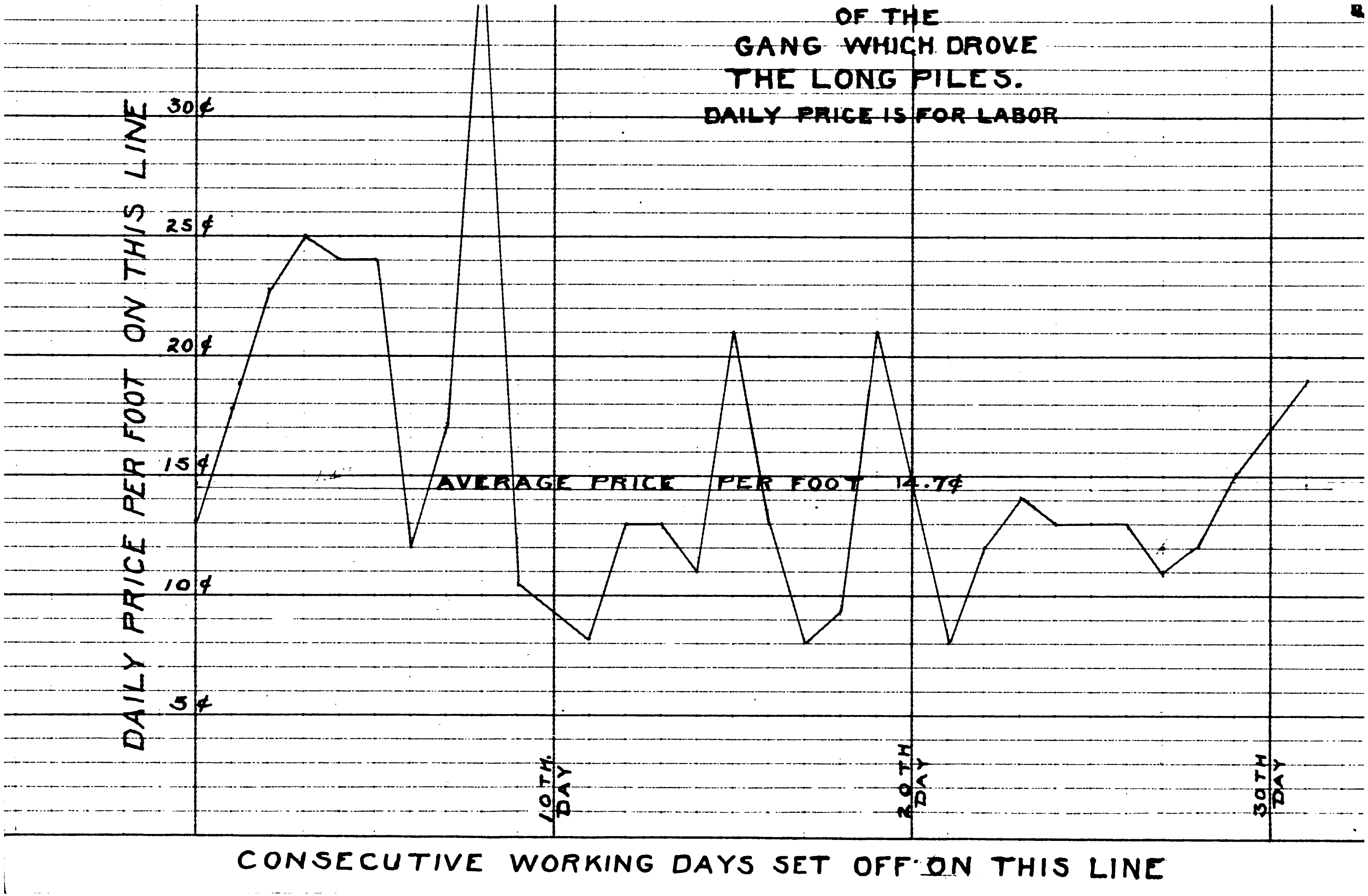
The water is conveyed from the south side to the north side of the Arkansas River, through a wooden stave pipe siphon laid three feet under the River bed. The bed of this river is subject to scour; therefore, the pipe was staked down by forty foot piles, driven in bents ten feet apart.

To drive these piles a forty foot derrick was constructed. No timber was available of large enough size for bed pieces or leads; therefore we hewed off four piles for bed pieces and built up the leads out of 2 x 8's. The photograph indicates the size and design of the driver, which cost $480.00 to construct. I rented a sixteen H. P. American Hoisting Engine, which with a fifty foot length of fire hose, a forty foot two inch W. I. jet, and an assortment of sheaves and blocks, together with a quantity of 1½" Manila Rope made up the driving outfit. The hammer used, to begin with, was a 1400 lb. hammer with a 16" face. The forty foot piles proved to be between 18" and 20" at the butts. I had the light hammer taken to the Beet Factory Repair Shop, and had cut two 2" slots across each side of the hammer. In these slots were bolted two inch bars of steel so that flat bars could be bolted to their projecting ends, thus making the hammer fit on leads 22" apart. Bolts were put through the flat



BEGINNING ROUND PILE DRIVING

SHOWING DRIVER AND JETTING PUMPS


OF THE
GANG WHICH DROVE
THE LONG PILES.
DAILY PRICE IS FOR LABOR
DAILY PRICE PER FOOT ON THIS LINE
30¢
25¢
20¢
15¢
10¢
5¢
AVERAGE PRICE PER FOOT 14.7¢
10TH. DAY
20TH DAY
30TH DAY
CONSECUTIVE WORKING DAYS SET OFF ON THIS LINE

bars to act as faces for the leads to bear against. It was not believed this arrangement would work, but we used it to drive over one-third of the piles. A larger and heavier hammer of 2500 lbs. weight was finally purchased because of the material met with. In connection with the driver we used a 2" jet which was supplied by a 6 x 10 x 8 Duplex Snow Pump. This being inadequate, when we got half way across the river, I secured a 4 x 6 x 4 Duplex Snow Pump from the Beet Company. The two pumps did very well. Steam was supplied by a 50 H. P. Erie Locomotive Boiler.

Temporary piles had to be driven to support the driver while the permanent piles were being driven, since for over half the distance, there was considerable water in the river. We were afraid to crib up on the river bottom because of scouring. The temporary piling increased the cost of driving about one-third.

All the piles went very hard because of a layer of blue clay under which was cemented gravel. We first put the jet down and were able to penetrate the clay with the jet but we could not wash out a hole as one can in sand. When the jet struck the gravel it was just as if it had brought up against a rock. If the movement of the jet would stop for a moment, the jet could not be pulled out. We would then have to uncouple the hose, put on another jet, and jet the first one loose. After the first few feet and down to twenty three feet when we got through the cemented gravel, it was simply a case of pounding the piles down. The drawing (PlateXV) shows the daily rate of progress made.

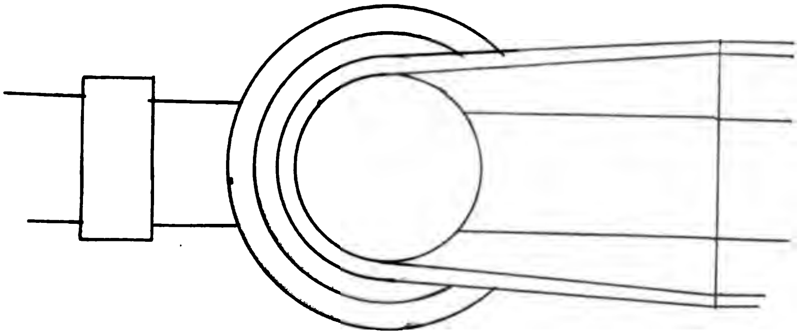
While the driver was putting in the piling we rigged up a small derrick and drove sheet piling by team. This was slow work and as soon as we finished the piling we turned the driver, came back across the tops of the piles, and drove with a hoist. In pulling the sheet piling we rigged up a gallows frame with two sets of falls, one for each side of the ditch. Holes were bored through the piling and a clevice pinned through the holes. The hook of the block was put through the clevice and a line to a nigger head of the hoist easily drew up the piles. About one half of the sheet piling had to be gone over and about one third of the boards were split and ruined after one driving, owing to the cemented gravel.

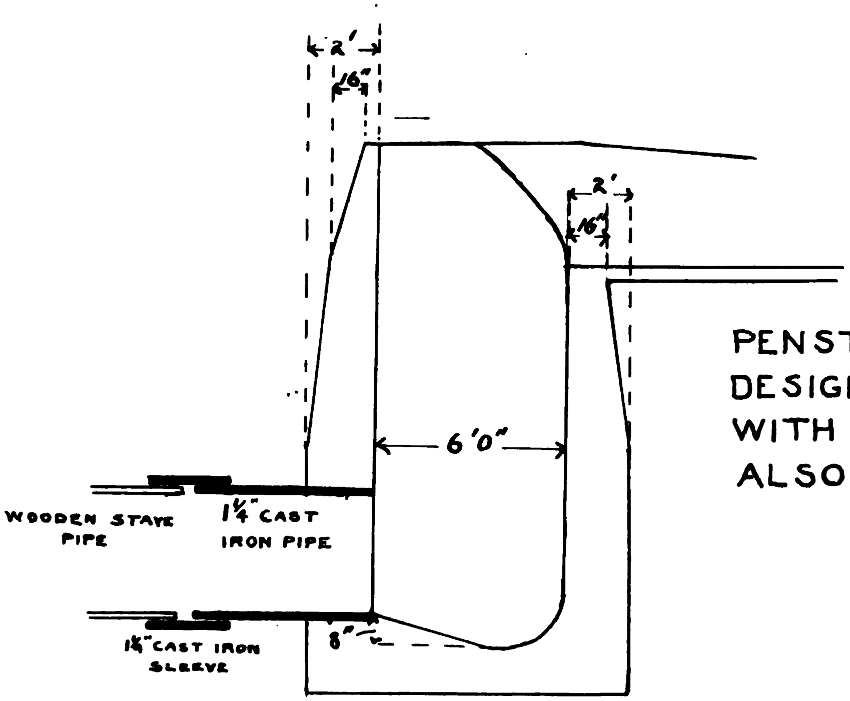
The river work was carried on in three eight hour shifts, lights being furnished by a 4½ H. P. gasoline engine belted to a small generator. The night work seemed to go on with the same measure of rapidity as the day work.

EXCAVATIONS:

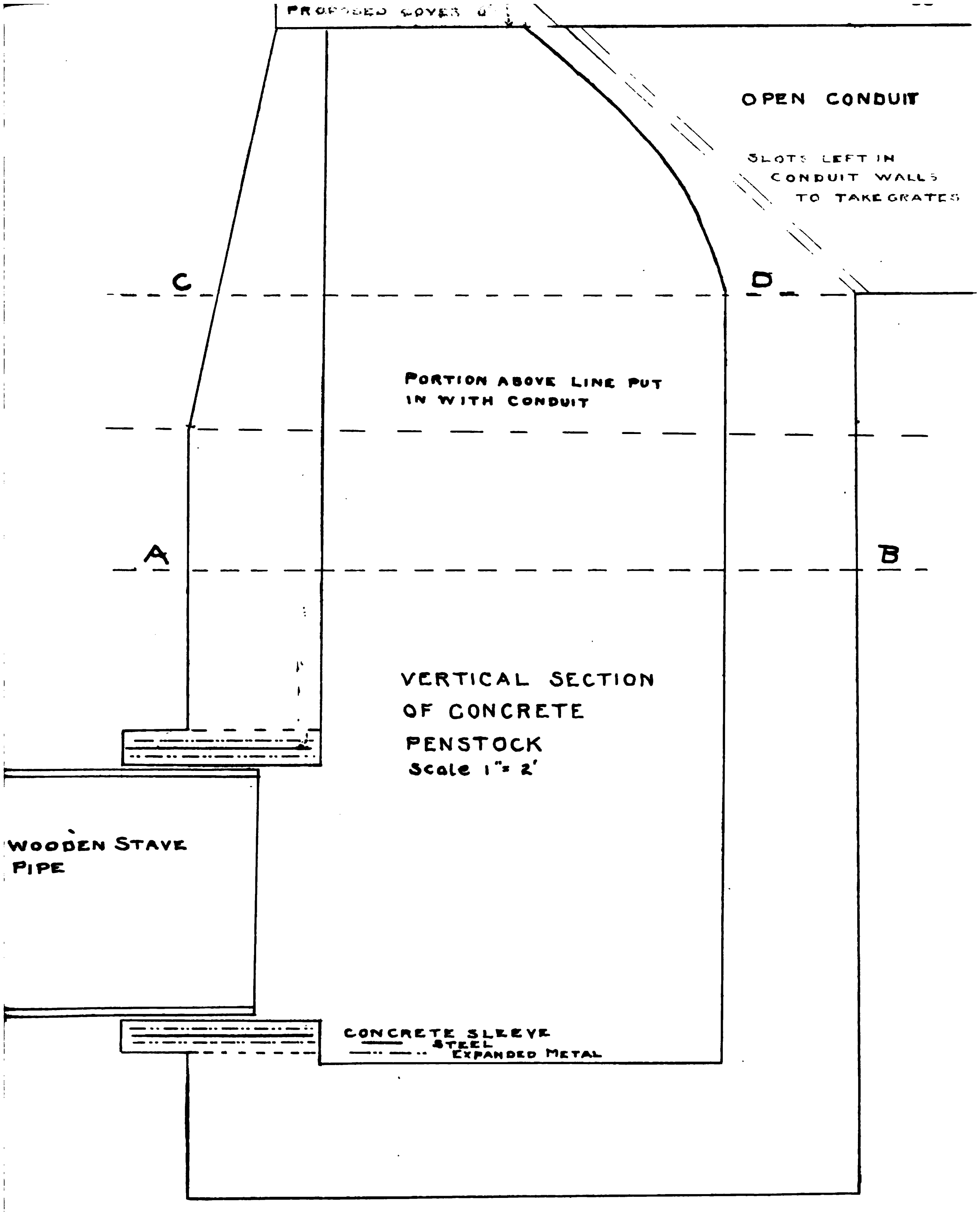
The excavation for the North Penstock was 16 feet sq. The sides were sheathed with three piece sheathing made of 2 x 10 x 16' plank, with a two inch tongue, nailed with 40 Py. spikes. The walls were braced by 6 x 6 timbers set cross ways and butting against 3 x 12's set horizontally. The excavation was done by shovel, the water being kept down by a 6" centrifugal direct connected pump, which was taxed to its capacity. The trench for the wooden stave pipe was a simple open sewer trench, the sides being sheathed with three

Plate XVI



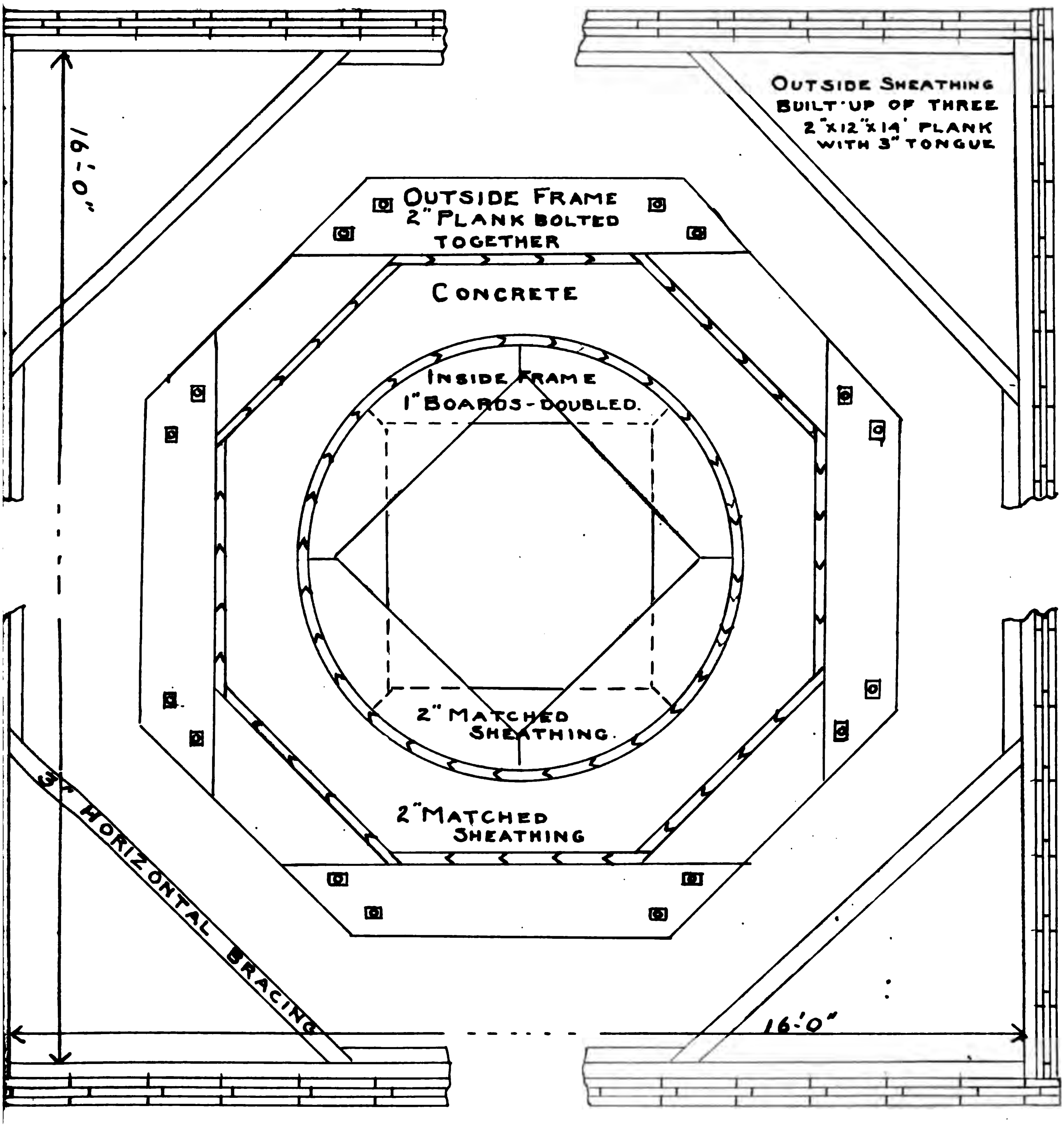


PENSTOCK AS DESIGNED. COMPARE WITH XVII AND XVIII. ALSO XIX.



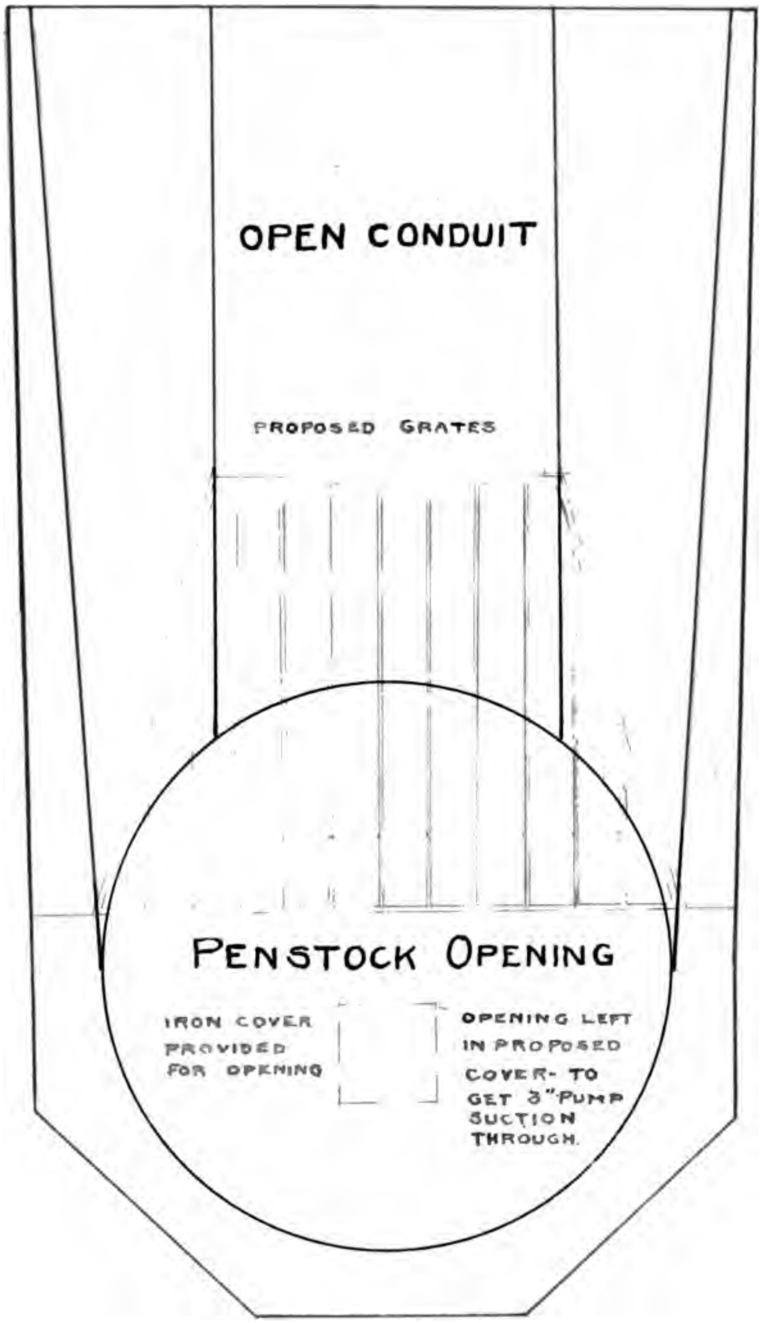
VERTICAL SECTION OF CONCRETE PENSTOCK
Scale 1" = 2'

Plate XVII



CROSS SECTION
OF PENSTOCK
SHOWING FORMS
ON SECTION A-B
DRAWING NO XVII
Scale 1"=2'

Plate XIX


OPEN CONDUIT
PROPOSED GRATES
PENSTOCK OPENING
IRON COVER PROVIDED FOR OPENING
OPENING LEFT IN PROPOSED COVER- TO GET 3" PUMP SUCTION THROUGH.

SECTION OF PENSTOCK
OVER SECTION C-D
OF DRAWING XVII
Scale 1"= 2'

piece sheathing, 12' long. Cross braces of ties and telegraph poles were used. The water was handled by two 6" centrifugal pumps. We provided long handled shovels which made only one staging necessary. Three handlings of the dirt put it on a pile well back from the edge of the ditch. As much as possible of the dirt was back-filled by shovel, the balance being wheeled in in barrows.

CONCRETE PENSTOCK:

The plan for the Penstock was not entirely followed as is indicated by drawings (Plates XVI toXIX) In making the final excavation, we built an octagon form of the size shown in place of a round form as called for. This was centered in the excavation and 4' tongue and groove sheathing was jetted down around the outside of the form. The interior was then excavated to the bottom of the Penstock floor. We had to couple a three inch pump driven by a 4 H. P. gasoline engine to help the 6" centrifugal keep the water down while making this excavation.

Having cleaned out the hole, we divided it by a bulkhead and put the suctions of both the 6" and 3" pumps in one side. By having enough concrete mixed up and by depositing it quickly, we got in one section of the floor. We then stopped the pumps and allowed the water to raise.

The next day we pumped the pit out and found the concrete hard. We dug a sump outside the octagon form and were able in this way to keep the water down sufficiently to get in the other portion of the floor. We used a great excess of cement in mixing this concrete but the result was

a hard floor.

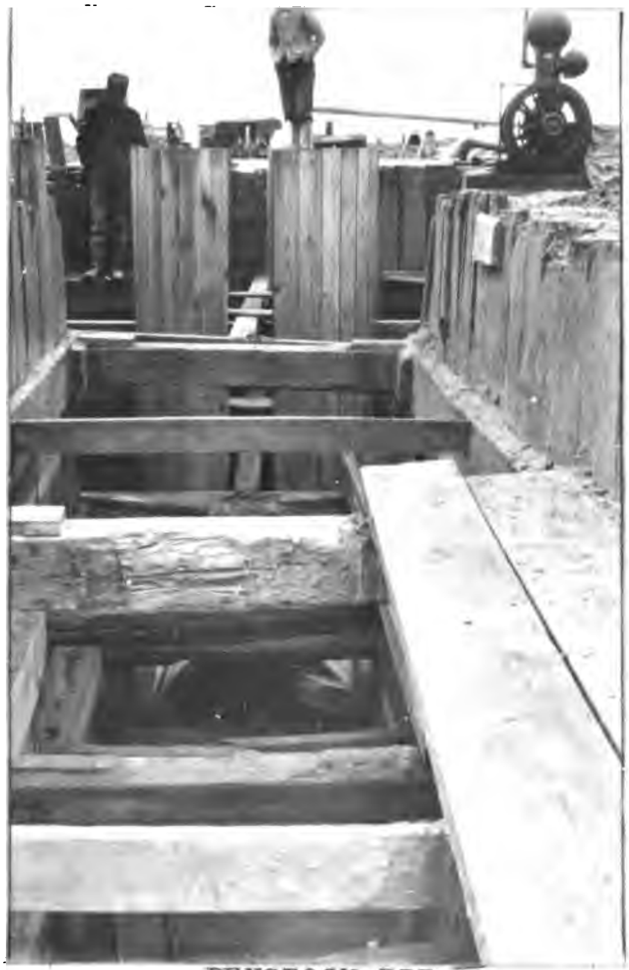
We next broke out the octagon form on the side where the opening of the wooden pipe came. We then lowered the 2000# concrete sleeve and cemented it in place. This sleeve is not as shown in the plan, but was made as shown on drawing, (PlateXVII) of a cylinder of boiler plate covered by concrete inside and outside, each layer of concrete being re-inforced by a sheet of expanded metal.

The sleeve being placed in position so that the center line of the sleeve was at the inside line of the penstock, the inside and outside forms for the concrete walls were built up. The outside form was made by standing 2" plank on end around the inside of the octagon form; the inside form was made by standing 8" tongue and groove sheathing around circular templates made of 1" lumber. Concrete was filled up to the height of the first 6 x 6 cross braces, whereupon the work was stopped until the concrete had hardened. 3 x 12 plank were then fitted in as shown on drawing (PlateXVIII) after which the cross braces were taken out and the form continued up and filled with concrete.

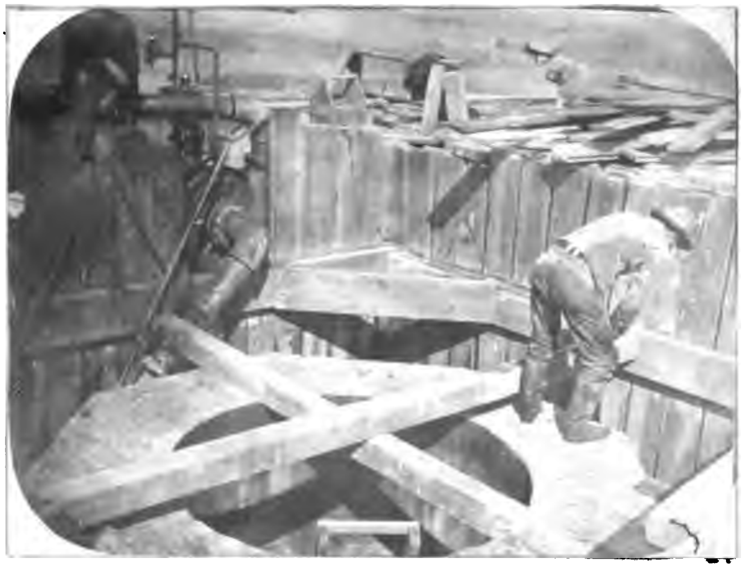
In making the juncture between the sleeve and the penstock form wooden staves were fitted in the inside of the sleeve and the ends cut to fit the vertical inside form of the penstock. This method was rapid and made a very neat looking job.

WOODEN STAVE PIPE:

The wooden stave pipe was made of 6" staves of long leaf Southern pine, with 4" oak tongues. The inside diameter is 42"; thickness of staves, 1 5/8".

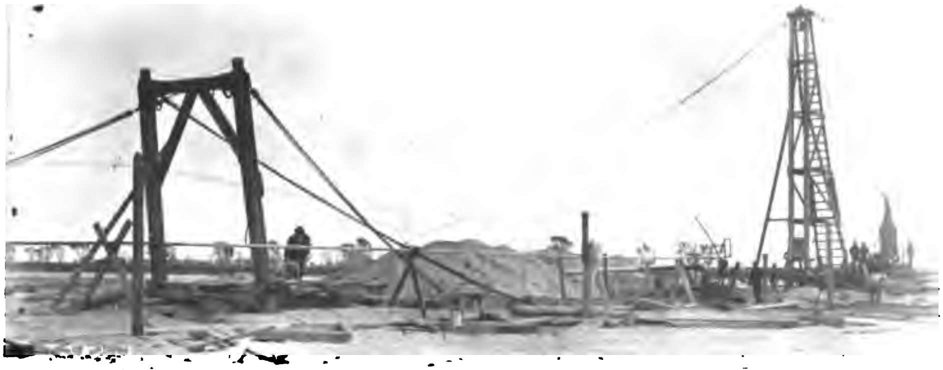


PENSTOCK PIT
SHOWING INSIDE FORM
AND
CONCRETE SLEEVE

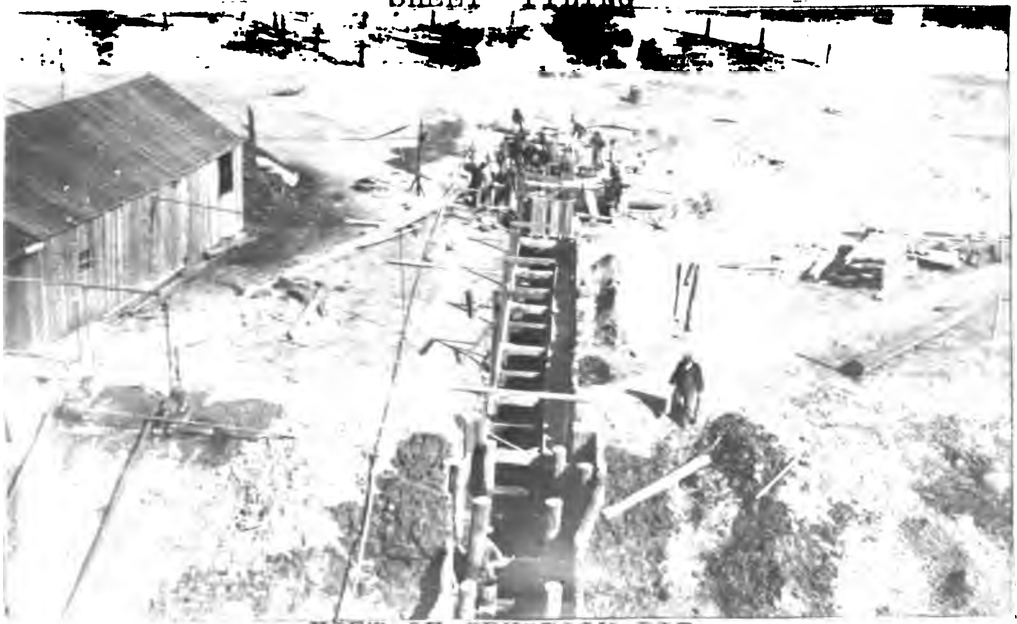


PENSTOCK PIT
SHOWING PENSTOCK

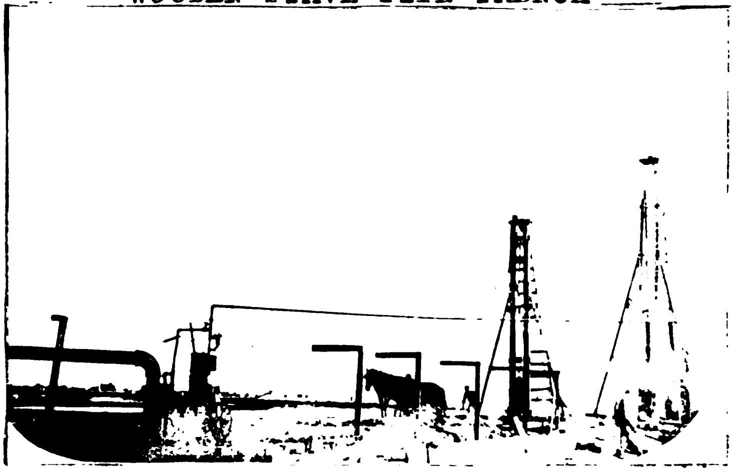
PLATE XX



SHOWING
OUTFIT FOR DRIVING AND PULLING
SHEET PILING



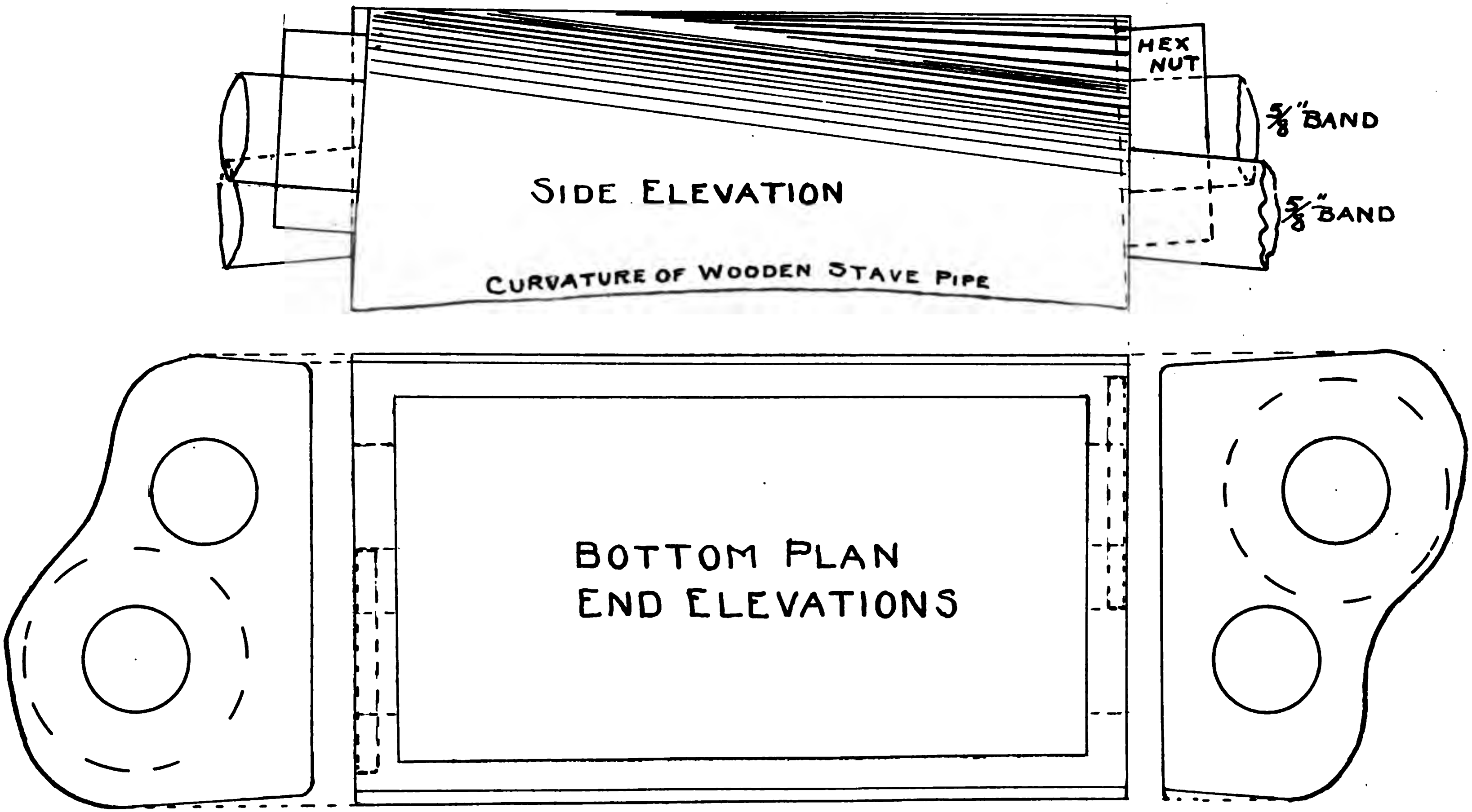
VIEW OF PENSTOCK PIT
AND
WOODEN STAVE PIPE TRENCH



HORSE DRIVER FOR SHEET PILING

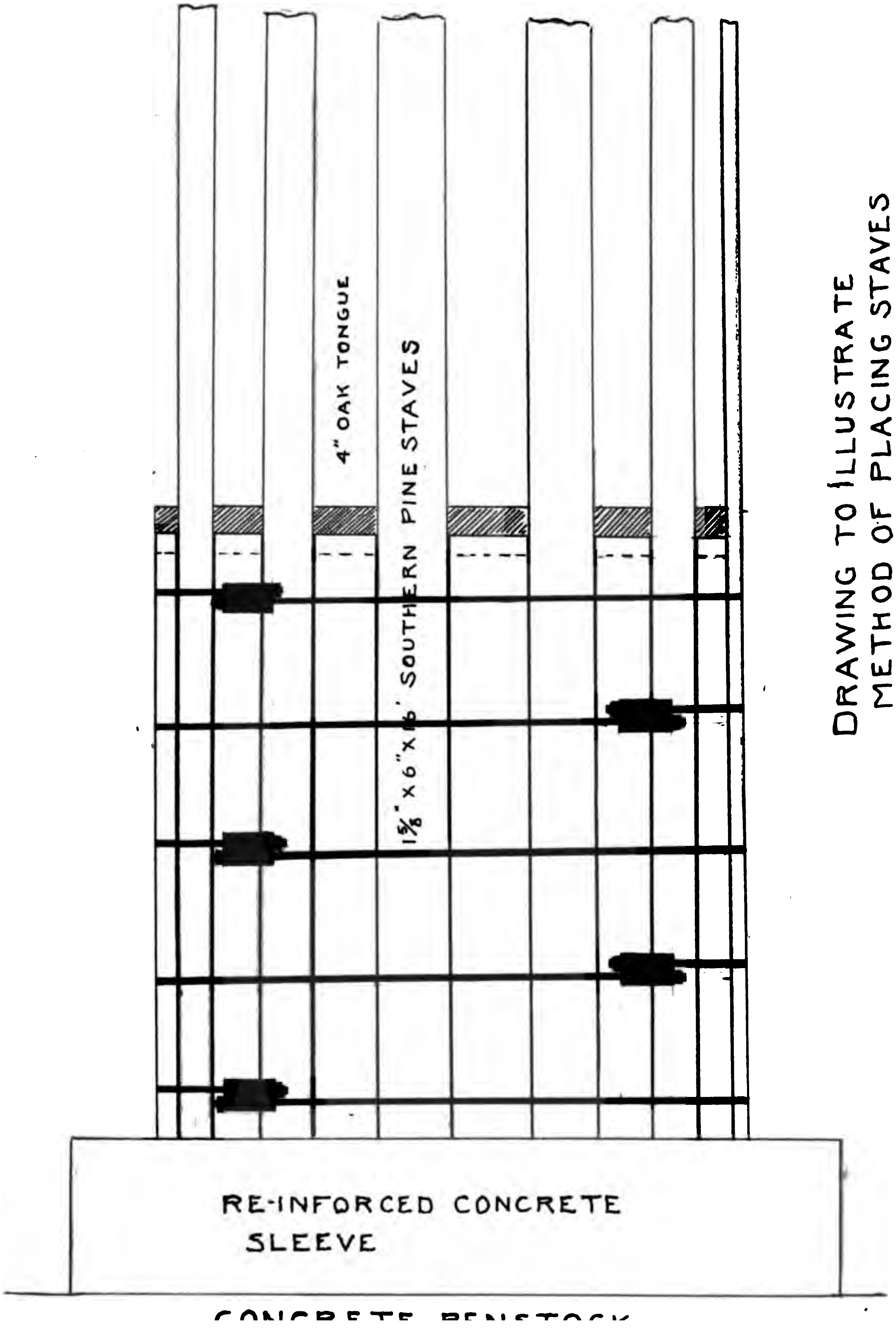
PLATE XXI

Plate XXII



DRAWING OF CLAMP
FOR
WOODEN STAVE PIPE
Scale=Full Size.

Plate XXIII


4" OAK TONGUE
1⅝" X 6" X 16' SOUTHERN PINE STAVES
RE-INFORCED CONCRETE SLEEVE
CONCRETE PENSTOCK

DRAWING TO ILLUSTRATE METHOD OF PLACING STAVES

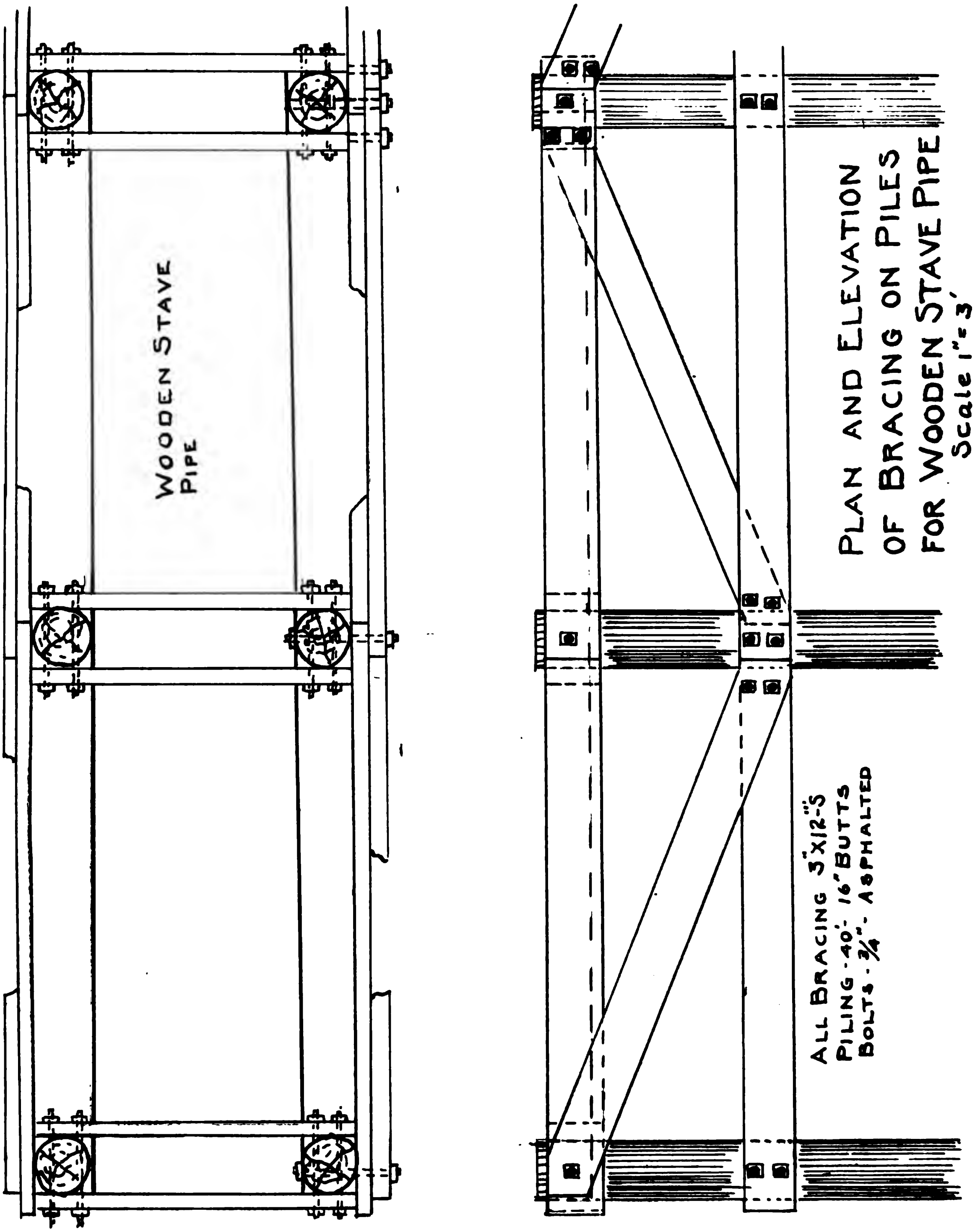
1-INCH = 1 FOOT.

The writer attended to getting the clamps for the bands which encircle the pipe every ten inches. Finding a high price was put on these clamps and not liking their cumbersome appearance he devised a casting which appears to be the simplest he has seen yet. The full size drawing (Plate XXII) indicates its appearance. The sweep was laid to the outside circle of the pipe and the holes for the bands were drilled in a chuck so as to line up perfectly. To meet a requirement that the nuts bear evenly over their whole surface the clamps were put in a second chuck and one hole at each end was faced to the proper angle. The rib through the center on top takes most of the strain, while the clamp is made narrow enough for the balance to be taken by the sides. The bands were shaped by an ordinary blacksmith's tire bender, and no difficulty whatever was found in getting the ends of the rods through the holes in the clamps, the avoidance of this difficulty being urged by most dealers in support of some particular clamp.

To guard against the action of the strong alkali water of this region on the iron, all iron was specified to be coated with an asphalt mixture. We tried asphalt, and a mixture of pitch and oil without success, as the coat cracked when the iron was tightened. We finally gave the bands two coats of asphalt paint, and when they were in place, swabbed them over with hot pitch.

In setting the staves the plan of breaking joints as indicated by drawing (PlateXXIIIwas followed. This method

Plate XXIV



PLAN AND ELEVATION OF BRACING ON PILES FOR WOODEN STAVE PIPE
Scale 1" = 3'

ALL BRACING 3"X12"-S
PILING-40'-16" BUTTS
BOLTS-3/4"-ASPHALTED

was not in agreement with the writer's idea, and his judgment was vindicated by practice. The writer wanted to have a spiral joint. This would make it unnecessary to drive a stake between the ends of two wet ones. We found that every stave swelled one-quarter of an inch in width. So long as the staves remained reasonably dry the method used was better because it left only eight feet of un-completed pipe projecting; whereas the writer's method would have left sixteen feet. When the staves were wet, by reason of the very frequent stopping of the pump, it would take nearly eight hours to get in one length of pipe.

The procedure was to drive in the topmost stave, then thread the bands over this stave and nail a brace to support the end projecting. Then the staves were put in in succession, the bands were spaced, and the staves hammered out from the inside while the bands were being tightened.

The piling were braced as shown on drawing (Plate XXIV) with 3" plank to prevent movement. Whenever the piling was out of line, we put the horizontal bracing on the inside, and the diagonal bracing on the outside. All the bolts were painted two coats of asphalt paint.

CHAPTER V

COST DATA

In the following tabulation of costs charges of freight are not included. The Government has special freight rates, owing to land grants, loans, etc., which are figured out at Washington and all carrier charges are paid at the Washington Offices.

EARTH WORK

In figuring the cost of earth work the cost of each operation is given separately. The specification provides for the removal of sod, building the embankment, settling the earth and finishing the grade, payment to be by yard on the basis of the barrow pit measurement. No comparison with competitive figures can be made because the only price bid was 25¢ per yard for the rough embankment work only.

NORTH CONDUIT EMBANKMENT:

Length of North Conduit Embankment	7,000 ft.
Number Cubic Yards of Sod Moved,	5,319
" " " " Earth Moved,	9,939
" " " " " Per Foot of Embankment	1.42

Following Costs include Rental, Superintendency and Office Expense.

Cost per yard, plowing sod	.04		
" " " moving "	.153		
" " " " and plowing		.193	
TOTAL COST OF SOD			$1026.00
Cost per yard plowing earth	.031		
" " " moving "	.198		
" " " " and plowing		.229	
TOTAL COST OF EARTH			2276.00

SETTLING FILL

Cost per foot of embankment	.021		
" " yard in terms of yardage moved		.01	
TOTAL COST OF SETTLING			$147.00

EXCAVATING EMBANKMENT

Cost per ft. of embankment	.23	
Cost per yard of embankment in terms of yardage moved	.106	
TOTAL COST OF EXCAVATING EMBANKMENT		1638.00

FINISHING EMBANKMENT

Cost per yard of embankment in terms of earth moved	.049	
TOTAL COST FINISHING EMBANKMENT		490.00

TOTAL AMOUNT EXPENDED..................................$5570.00

COST PER YARD OF MATERIAL MOVED........................ .35

SOUTH CONDUIT EMBANKMENT

Length of South Conduit Embankment	4,600 Ft.
Number of Cubic Yards of Sod moved	4,767
" " " " " Earth " by slip	9,927
" " " " " " " " wheeler	20,000
" " " " " " ,per ft. of embankment	6.07

Following costs include Rental, Superintendency and Office Expense Charges.

SLIP WORK

Cost per yard plowing sod	.04		
" " " moving "	.136		
" " " " plowing		.176	
TOTAL COST			839.00

Cost per yard plowing earth	.06		
" " " moving "	.18		
" " " " and plowing		.24	
TOTAL COST			2382.00

WHEELER WORK

Cost per yard plowing earth	.06		
" " " moving "	.24		
" " " " and plowing		.299	
TOTAL COST WHEELER WORK			5997.00

SETTLING FILL

Cost per foot of embankment	.08		
" " yard in terms of material moved		.011	
TOTAL COST OF SETTLING FILL			$350.00

EXCAVATING AND FINISHING EMBANKMENTS

Cost per foot of embankment	.195	
Cost per yard of embankment in terms of material moved	.03	
TOTAL COST EXCAVATING AND FINISHING EMBANKMENTS		898.00

TOTAL AMOUNT EXPENDED	$10463.00
COST PER YARD OF MATERIAL MOVED........................	.34

CLOSED CONDUIT EXCAVATION

Length of Closed Conduit Excavation	6,500 ft.
Cubic yards of dirt excavated by Scraper	2,000
" " " " " " Hand	2,200

Following costs include Rental, Superintendency and Office Expense Charges.

SCRAPER WORK

Cost per yard, plowing	30¢			
" " " scraping	30¢			
" " " " & plowing			60¢	
" " foot of ditch		.189		
TOTAL COST				1232.00

HAND EXCAVATION WORK

Cost per yard of earth	88¢		
" " foot " ditch		.297	
TOTAL COST			1941.00

TOTAL AMOUNT EXPENDED..................................	$3173.00
COST PER YARD OF MATERIAL MOVED.........................	.76

CONCRETE WORK

FARMERS' DITCH LINING

Number of yards of concrete	70
" " bbls. " cement	84
" " " " to yards concrete	1.2

Cost cement	$140.00
" sand	12.00
" hauling	98.00
" mixing and placing	74.00
" excavating	48.00
" form setting	21.00
" Rental, Superintendency & Office Expense	20.00

TOTAL COST...$413.00

Cost per yard of concrete	5.90	
Best price bid	8.50	
Saving to Government		182.00

This piece of concrete offered the best opportunity on the conduit for using the mixture, and the price per yard, as compared with the prices which follow, indicates that much of the expense of mixing and placing was due to having to move the mixer so frequently.

OPEN CONDUIT

Length of conduit,	7,000 ft.
Number of Yards of Concrete,	1,200
" " " . " " used per ft. of Conduit	.171
" " Bbls. " Cement used	1,625
" " " " " " to 1 yd. " Concrete	1.35

Cost Cement	$3272.00	
" Sand	221.00	
" Hauling	3135.00	
" Mixing & Placing	2227.00	
" Rental, Superintendency and Office Expense	500.00	
TOTAL		$9355.00

Cost per foot of ditch	$1.33	
" " yard " concrete		$7.79

FORM SETTING

Length of Conduit	7,000 ft.
Area of Form Set	58,800 sq.Ft.

Cost Lumber	$270.00	
" Labor	613.00	
" Superintendency, Rental & Office Expense	125.00	
TOTAL...		$1008.00

Cost per ft. of Conduit	.144	
" " sq. ft. form set	.017	
" " yd. of Concrete		.84

EXPANSION JOINTS

Length of Conduit		7.000 ft.
" " Joints		2,760 ft.
Cost of Mixture	$27.00	
" " Labor	66.00	
TOTAL	$93.00	93.00

Cost per ft. of Joint	.04
" " " " Conduit	.013
" " yd. " Concrete	.0775

Cost of

PLASTERING

Cost per sq. ft. plastered	.007
" " ft. of Conduit	.069
" " yd. of Concrete	.40

TOTAL EXPENDITURE.................................$10936.00

COST CONCRETE PER YARD, COMPLETE	$9.11	
Best price bid	8.50	
Loss to Government, per yard	.61	
" " " Gross		732.00

The cause of the high price for this concrete is the price paid for Sherlock Screened Gravel, 1050 yards being used at $2.50 per yard, plus 15¢ for the gravel. The coarseness of this gravel also added to the expense by taking more cement. I brought this matter to the attention of the Engineer prior to the receipt of the gravel. He had had a hard time to get cars from the railroad to bring in a certain small amount of screened gravel needed at the Power House, and decided he could not honestly stop using the cars when the small amount was delivered. I estimate the Government lost 75¢ per yard on 1050 yards of gravel or $787.00; also $600.00 on cement, and at least $50.00 on plastering. The efficiency with which the work was done - approximately $2.00 per yard for mixing and placing - indicates the high price was due to the cost of the materials alone.

CLOSED CONDUIT

MACHINE MIXING

SIDES & BOTTOM

Length of Conduit	3,600 ft.
Cubic yards of concrete,	600
" " " " per foot of Conduit	.166
Number of bbls. of Cement	619
" " " " " to 1 yd. Concrete	1.03

Cost Cement	$1238.00	
" Sand	98.00	
" Sand Hauling	390.00	
" Mixing & Placing	1030.00	
" Equipment (Less Salvage)	75.00	
" Superintendency, Rental & Office Expense	400.00	
TOTAL COST....................................		$ 3231.00

Cost of Mixing and Placing per ft. of Conduit $1.02
" " " " " " yd. " Concrete 5.385

FORM SETTING

SIDES & BOTTOM

Length of Conduit	3,600 ft.
Area of Forms Set	13,890 sq ft

Cost of Lumber	$90.00	
" " Labor	301.00	
" " Rental of Equipment, Superintendency and Office Expense	50.00	
TOTAL..		$ 441.00

Cost per sq. ft. of form set	.032		
" " ft. of Conduit	.122		
" " yd. of Concrete		.735	
TOTAL EXPENDITURE............................			$3672.00

TOTAL COST CONCRETE PER YARD...................... 6.12

Best bid on concrete received	$8.50	
Saving to the Government		$ 1378.00
Loss to the Government on Open Conduit		732.00
BALANCE PROFIT TO GOVERNMENT......................		$ 646.00

This comparison is according to the requirements of specification. The quotation $8.50 did not include the expansion joints.

HAND MIXING

SIDES & BOTTOM

Length of Conduit	7,000 ft.
Cubic yards of concrete,	400
" " " " per ft. of Conduit	.10
Number of bbls. of cement	441
" " " " " to 1 yd. concrete	1.10

Cost cement	$882.00	
" sand	57.00	
" " hauling	285.00	
" mixing and placing	1140.00	
" equipment (less salvage)	25.00	
" Superintendency, Rental and Office Expense	200.00	
TOTAL		$2589.00

Cost 37¢ 3

" $6.47

FORM SETTING

SIDES & BOTTOM

Length of Conduit	4.000 ft.
Area of Forms Set	12.680 sq.Ft

Cost Lumber	$120.00	
" Labor	305.00	
" Rental, Superintendency, & Office Expense	50.00	
TOTAL		475.00

Cost per sq. ft. of form	.038	
" " ft. of Conduit	.118	
" " yd. of Concrete		$1.18

TOTAL EXPENDITURE	$3064.00
TOTAL COST CONCRETE PER YARD	7.65

While it is apparent that Machine Mixing is cheaper than Hand Mixing, as is shown by the saving in cement to start with, the two results are not strictly comparable be-

cause the cross section of the hand mixed concrete is less than that of the machine mixed concrete. Using the machine o on the smaller cross section would have necessitated more frequent moving of the machine, which would have increased the cost per yard. However, the above results show in favor of the machine.

TOP

Length of Top	7,000 ft.
Cubic Yards Top	325
" " " to 1 ft. Conduit	.046
Number bbls. Cement	408
" " " to 1 yd. concrete	1.26
(Purposely made very rich)	

Cost Cement	$816.00	
" Sand	54.00	
" Sand Hauling	241.00	
" Mixing and Placing	707.00	
" Superintendency, Rental &Office Exp.	250.00	
TOTAL..		$2068.00

Cost per ft. of Conduit Top	.295	
" " yd. of Concrete		$6.36

REINFORCING

Cost of Steel, cut to length			375.00
" per foot of Top	.054		
" " yard of Concrete		$1.15	

FORM SETTING

Length of Top	7,000 ft.
Area of Forms	22,430 sq.ft.

Cost of Lumber	$60.00	
" of Labor	430.00	
" Rental, Superintendency, & Office Expense	100.00	
TOTAL		$ 690.00

Cost per sq. ft. of form	.03			
" " ft. of top		.098		
" " yd. of concrete			$2.43	
TOTAL EXPENDITURE ON TOP				$3133.00

TOTAL COST OF TOP, PER YARD........................ 9.94

TOTAL EXPENDITURE CLOSED CONDUIT..................$9879.00

Averaging Machine and Hand Mixed Concrete in sides and bottom, and top, per yard, for purposes of comparison $7.46

WOODEN STAVE PIPE

ROUND PILING

Cost of Piles	$1041.00	
" " Unloading and Hauling	104.00	
Proportionate Cost of Driver	240.00	
Cost of Labor	975.00	
" " Coal	133.00	
Proportionate cost of Equipment	500.00	
Rental, Superintendency and Office Expense	250.00	
TOTAL COST..		$3243.00

Lineal feet driven	6,610 ft.	
Cost per ft. of piling driven	49¢	
Cost per ft. of pipe line		7.89

SHEET PILING

DRIVING AND PULLING

Cost of Piling	$450.00	
" Labor of Making	138.00	
" Labor Driving	1310.00	
" Equipment	500.00	
" Rental, Superintendency & Office Expense	400.00	
TOTAL..		$2798.00

Lineal Feet Driven	9,864 ft.	
Cost per lineal foot	28¢	
Cost per sq. ft. ditch sheathed	28¢	
" " ft. pipe line		6.80

EXCAVATING AND BACK FILLING

Number of yards excavated	1,320
" " " handled	2.640

Cost of Labor	$1503.00	
" " Pumping and Coal	350.00	
" " Equipment	450.00	
" " Rental, Superintendency and Office Expense	400.00	
" " Electric Lights	200.00	
TOTAL.......		$2903.00

Cost per yard excavated	$1.10
" " foot of pipe line	7.06

CONCRETE PENSTOCK

Number of cubic yards of concrete	26.4

Cost of Cement	$80.00	
" " Gravel	65.00	
" " Lumber Forms	30.00	
" " Labor Forms	60.00	
" " Pumping	15.00	
" " Labor, mixing and placing of concrete	127.00	
" " Equipment	50.00	
" " Rental, Superintendency and Office Expense	50.00	
TOTAL		$ 505.34
COST PER YARD OF CONCRETE		19.78

This cost is not unreasonable considering the nature of the work. The price includes the cost of making and setting the concrete sleeve.

WOODEN STAVE PIPE

Cost of Staves	$420.00	
" " Lumber for Pile Bracing	525.00	
" " Bands, Asphalted	288.00	
" " Clamps "	62.00	
" " Bolts, "	75.00	
" " Labor, Laying Pipe	321.00	
" " " Bracing Piling	120.00	
" " Pumping	150.00	
" " Equipment	400.00	
" " Rental, Superintendency and Office Expense	200.00	
TOTAL		$ 2561.00
COST PER FOOT OF PIPE		6.24

SUMMARY

EARTH WORK

NORTH CONDUIT
Cost per yard of material moved ....35¢
TOTAL AMOUNT EXPENDED..............................$ 5570.00

SOUTH CONDUIT
Cost per yard of material moved..........34¢
TOTAL AMOUNT EXPENDED.............................. 10463.00

CLOSED CONDUIT
Cost per yard of material moved..........76¢
TOTAL AMOUNT EXPENDED.............................. 3173.00

CONCRETE WORK

FARMER'S DITCH
Cost per yard of concrete..............$5.90
TOTAL AMOUNT EXPENDED.............................. 413.00

OPEN CONDUIT
Cost per yard of conduit................9.11
TOTAL AMOUNT EXPENDED.............................. 10936.00

CLOSED CONDUIT Machine Mixed
Cost per yard of conduit............... 6.12
TOTAL AMOUNT EXPENDED.............................. 3672.00

CLOSED CONDUIT Hand Mixed
Cost per yard of conduit............... 7.65
TOTAL AMOUNT EXPENDED.............................. 3064.00

CLOSED CONDUIT TOP Hand Mixed
Cost per yard of top................... 9.94
TOTAL AMOUNT EXPENDED.............................. 3133.00

WOODEN STAVE PIPE

CONCRETE PENSTOCK
Cost per yard of concrete..............19.78
TOTAL AMOUNT EXPENDED............................. 505.00

TOTAL $40929.00

SUMMARY--Continued.

TOTAL, AMOUNT FORWARD		$40929.00
COST PER FOOT OF WOODEN STAVE PIPE		
Round Piling	$7.89	
Sheet Piling	6,80	
Excavation	7.06	
Laying Pipe and Bracing Piles	6.24	
TOTAL	$27.99	
TOTAL AMOUNT EXPENDED		II505.00
TOTAL AMOUNT EXPENDED on the above listed Features, up to May 31st. I907,		$52434.00

CHAPTER VI

Summarizing my experience on this sample of management of work for the Government, I have been most impressed by the way one is handicapped in trying to do work quickly. It is not to be wondered that Contractors charge such a premium for undertaking Government work, and the reason is not far to seek why so many Contractors on Government work. fail. If the Government only realized how it conducts its work, and the way it delays complying promptly with the provisions of its own contracts, thus causing contractors to increase their rates as the only measure of self-protection left them, it is certain that many practices on the part of the Government would be changed. Consider, for example, the delay on the part of the Government in approving contracts made by its officers; take, for instance, the writer's own case -- when the contract which he signed on October 2d was not approved until January 16th -- and on which the first monthly payment, as provided by the contract, was not made until February 1st, by which time one third of this work was completed. Again -- the writer rented a certain hoist, saving, thereby, some $350.00 to the Government, on December 28th, 1908. The hoist is still in use (May 31st) yet the owner has not received a cent of rent which the contract provided he should receive, monthly. The time has expired when this hoist was to be returned. If payment is delayed much longer, the owner will become exasperated; the hoist will have to be returned at once, when two weeks' more time will finish the work; and thus the Government will lose

in freight charges in getting another hoist (not to mention lost time) all the writer gained to start with. Every contract is delayed in this way. The Government should promptly approve or disapprove contracts made by its agents. The writer recently brought the fact of this unfailing and unreasonable delay to the attention of the Director of the Reclamation Service; he was exceedingly surprised, and, after looking into the facts, from our office records, he declared he should investigate the cause upon his return to Washington.

Next to the delay is the cumbersome formality required. No short cuts are possible. You are prescribed, for instance, how you shall keep costs by the set provisions of a circular sent to all the Projects. The circular might fit one Project, but it certainly did not fit this one, as the writer indicated in the first chapter. in describing the method of cost keeping used. You could not purchase goods if you saw a bargain except by breaking a dozen rules. More latitude should be given an Engineer in making purchases of less than $500.00.

CHANGES IN THE PLANS

There is one general change I should make in the whole set. I should never hand a contractor a set of plans drawn to a scale of feet and tenths of feet. Plans to work from should be in feet and inches so that a foreman could interpret them and get his dimensions with a two foot rule. Lumber is not cut in tenths of feet; consequently no dimensions for forms except those in full feet could be gotten by using lum-

ber of commercial size.

From the experience gained I should make the following specific changes in the plans if they were to be used on another similar piece of work. I should keep from these or any plans all phrases and sentences as the following:

> "All embankments shall be made at such times, in such manner, and of such material as the engineer may direct; and under the bottom and side slopes of the conduit the embankment shall be well wetted, rolled and tamped until compacted to the satisfaction of the engineer".

Now, that is a pernicious statement, because there are no qualifications as to where the earth is to be obtained; when the work is to be done; or why it should be stopped; and because it definitely, in another section, states that a bidder must visit the premises prior to bidding, and that the Government is not to be bound by any information or instruction received from the engineer or his assistants. Thus a bidder must provide for all the contingencies suggested by such statements. I should state in the plans where the dirt was to come from; I should state what manner of doing the work would not be allowed, and what material would not be accepted. The only manner I should have excepted is by an elevating grader; the only materials I should have excluded are rock, sod and vegetable matter. The specification further excludes work in freezing weather, which is a foolish stipulation for this region, as if I had followed this condition, the work would have been delayed a month. By breaking the frost each day we managed to continue work, for, by so doing, the frost had no chance to go deep. A day's warmth took the frost out of

the lumps in the fill -- whereas a sheet of frost would hold. We put the dirt in in layers -- but we did not "roll, wet or tamp it". In the writer's opinion, it is not sensible to write a specification that you would not follow yourself.

The plans abound in phrases unfair to both Government and contractor, alike. Another follows:

> "The sod shall be removed and placed where directed by the Engineer -- and, if found suitable as a top dressing on the slopes of the embankments, it may be used as such";

or it may not; though whether it is or not does not depend on whether it is suitable or not. It depends, from the wording, simply on the whim of the engineer. As a matter of fact, we never thought of using sod. Instead, when the banks were put up, I had a portion of the black dirt saved, which was scooped up when the banks were finished and used as a top dressing.

In drawing up a specification, particularly a specification for Government work, I should take particular care to state what I should not allow, and I should leave as little as possible "to the satisfaction of the engineer". A contractor has no recourse in law against the Government, or the Government's agents. Every effort should be made to put reliable data in the hands of the contractor. It should be the engineer's business to inform himself before work is let, as to what is to be done after the work is let; he should then impart, and be responsible for imparting in writing, his decisions to responsible bidders, in answer to their inquiries, to enable the bidders to estimate honestly for their own, as well as the Government's

interests. The engineer should draw his plans and specifications exactly as he would want them for his own guidance if he were to do the work himself for his Government.

EARTH WORK:

I should give the tops of the banks supporting the open conduit a slope towards the ditch, and not make them, as provided by the plans, level. I had this plan followed after we had completed finishing the first three thousand feet of the North Conduit, because we found that the rain did not have such a good opportunity to gully the slopes.

I should have the specification call for seeding the banks as rapidly as they were finished, with seed of some such growth as Bermuda Grass, to prevent the winds of this region -- and the rains -- causing waste.

CONCRETE WORK:

There is one general change I should make. Drawing my plans to a scale in inches, I should chose dimensions so that the stock widths of lumber could be used in the forms. We simply did not attempt to strictly follow the conduit dimensions. The following tabulation of dimensions, taken from the plans, shows why it would have been impracticable to do so:

TABLE OF DIMENSIONS

CLOSED CONDUIT

STA.	to STA.	INSIDE DIMENSIONS	OUTSIDE DIMENSIONS	½" ROD SPACE
0	12	2.0' x 1.35'	2.5' x 1.35' & 7"	
12	20	2.6' x 1.65'	2.6'& 8" x 1.65' & 8"	20"
20	30	2.9' x 1.8'	2.9'& 8" x 1.8' & 9"	18"
30	40	3.3' x 2.0'	3.3'& 8" x 2.0' & 10"	16"
40	50	3.6' x 2.15'	3.6'& 8" x 2.15'& 10"	14"
50	60	3.9' x 2.3'	3.9'&10" x 2.3' & 10"	12"
60	69 & 27	4.1' x 2.4'	5.1' x 2.4' & 10"	12"

OPEN CONDUIT

70 & 7	80	3.2'	20"
80	90	3.3'	20"
90	100	3.4'	20"
100	130	3.65'	
130	200	4.20'	

In the open conduit, in changing from 3.65' to 3.2 (imagine getting a conduit side wall form to a hundredth of a foot) we took off a 12" board and put on an 8" board, instead. But it must be remembered that if a contractor had had this work, he would have charged the Government on the basis that he might have to abide by the plans to the letter. Undoubtedly he would have neglected to make his forms closer to 3.65' than 3' 8".

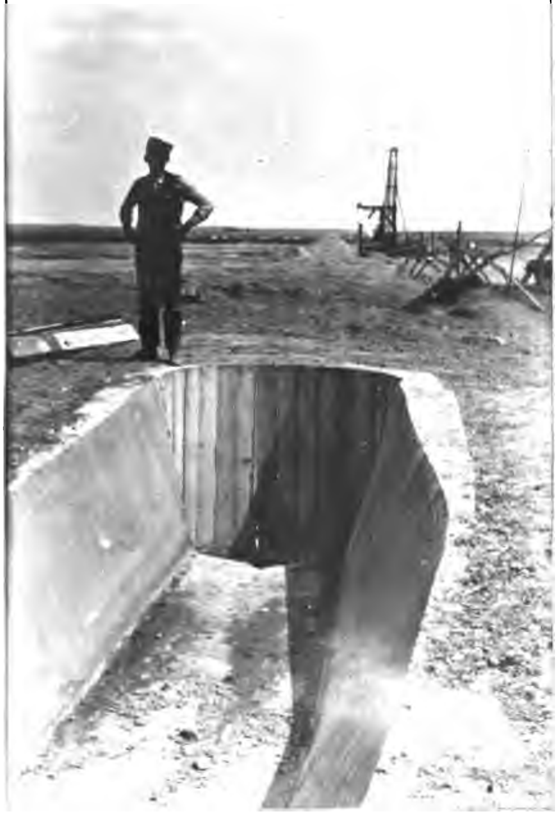
FARMERS' DITCH:

I should have planned the opening into the Farmers' Ditch as indicated in red on Drawing(Plate XI). The water would be spread out, the velocity decreased, and there would be less wash than I think there will be under the present design.

OPEN CONDUIT:

The plans call for an expansion joint "filled with a mix-

Plate XXV



PENSTOCK OPENING

ture consisting of 25% asphalt, 25% roofing tar, and 50% sand". In place of this, I should use a caulked joint filled with oakum soaked in hot pitch.

WOODEN STAVE PIPE:

I should have provided a concrete cover for the Penstock openings, as indicated in red on Drawing. (Plate XVII) I should also have provided slots in the walls of the open conduit sloping forward from the upper edge of the Penstock bore wher it meets the open conduit. Into these slots, grates could be slipped where the water was not running so as to prevent tumble weeds from filling the penstock. I spoke of this at the time the open conduit was finished. Now, after two weeks, there is a wagon load of water-soaked weeds in there already.

Attention is drawn to a comparison between the drawings, (Plates XVI) and (XVII) which indicates the change in the plan of the concrete Penstocks. Unless a particular shape is necessary, care should be taken in designing concrete to provide for as much simplicity as possible in the forms. Round shapes should be avoided, as they are expensive. It should be remembered in this particular case that the whole penstock is covered with dirt, so nothing would be gained by appearances. The writer believes the expense of the forms as called for would have been over double the cost of the form as used.

The plans for the pile bracing provides that the lower horizontal bracing be a foot lower than shown on Drawing,

(Plate XXIV) This would have necessitated a foot additional digging in the sand over the bottom of the whole trench. We raised the bracing a foot as shown -- the lower edge being on a line with the outside bottom of the Wooden Stave Pipe.

I should have left out the diagonal pile bracing. In the writer's opinion, it is unnecessary, as no pressure at right angles to the direction of the current will ever come on the piles. This would save about one third of the pile bracing cost.

I should change the specification relating to piling reading as follows:

"They shall be driven vertically by means of a hydraulic jet to a depth of forty feet".

I should word it

"Piles shall be driven vertically to a depth of forty feet, or to a refusal, or until the driving begins to crack the pile, as instructed by the engineer's assistant; payment to be per foot for piles in place."

As a matter of fact, there is not a forty foot pile in the river; they were driven in accordance with the above worded specification, because it was impossible to drive them "to a depth of forty feet", and the portion above grade cut off.

In the handling of the work I could think of but one important change I could make. In building the grade for the South Side Open Conduit, I should have built the grade solid; with no ditch. Then I should have taken one horse slips and should have pulled the dirt from the ditch each way to fill up the gaps left by which the wheelers got up onto the

grade. This would have done away with the long runs of the wheelers in finishing the grade, and would have decreased the cost of the fill per yard very materially.

Approved

W. D. Pence.

Daniel W. Mead

Leonard S Smith

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